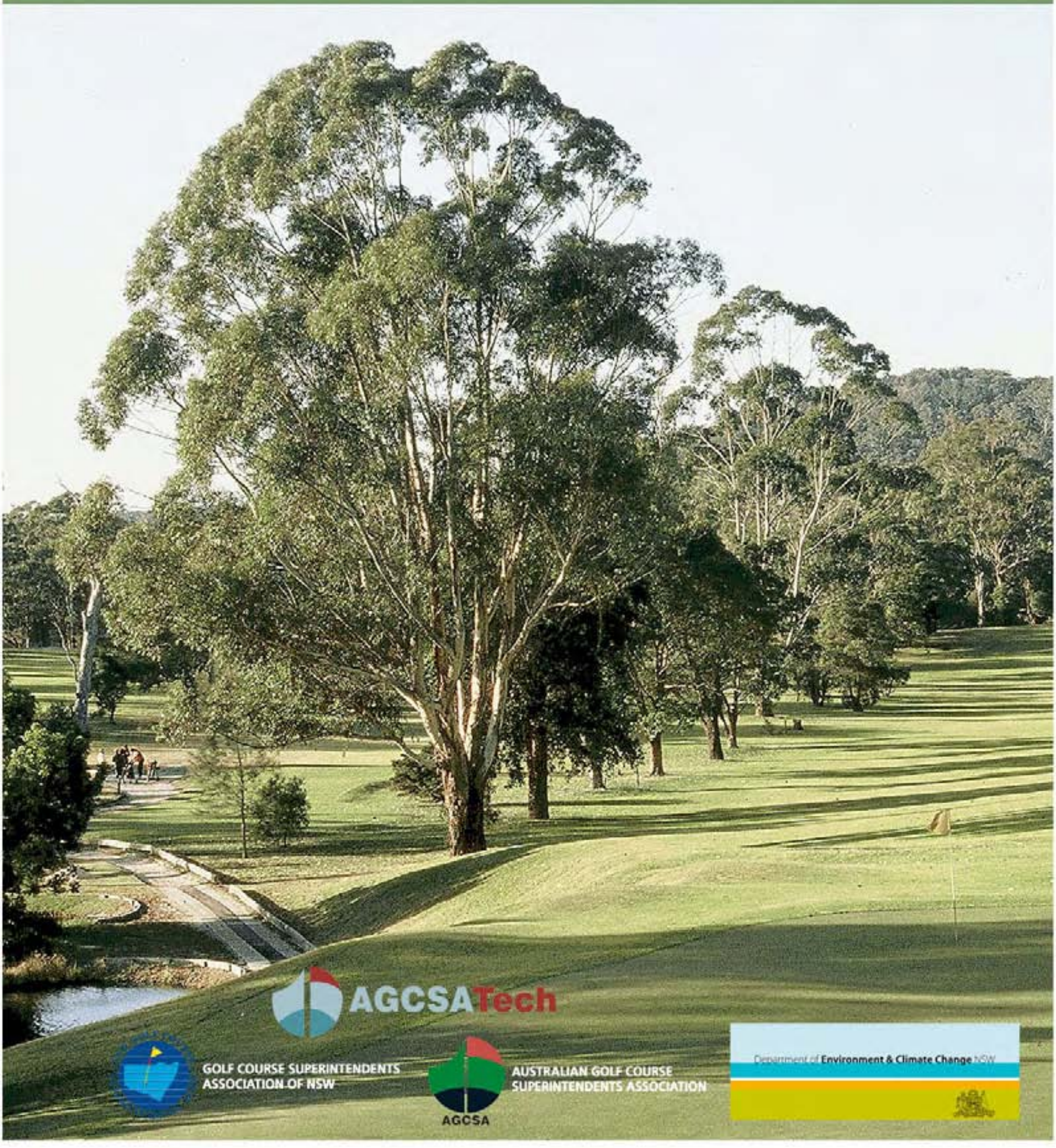
our environment it's a living thing

Improving the Environmental Management of New South Wales Golf Courses



AGCSATech

GOLF COURSE SUPERINTENDENTS ASSOCIATION OF NSW

AGCSA AUSTRALIAN GOLF COURSE SUPERINTENDENTS ASSOCIATION

Department of Environment & Climate Change NSW

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Contents

INTRODUCTION

This educational reference manual has been produced by the Australian Golf Course Superintendents Association (AGCSA) and the NSW Department of Environment and Climate Change (DECC) with funding from the Urban Stormwater Education Program through the Stormwater Trust. The Urban Stormwater Education Program aims to educate the community, industry, local councils and other stakeholders about ways to reduce urban stormwater pollution. It is a key component of the Urban Stormwater Program and the NSW Government's Waterways Package, which address the issues of water quality management and water pollution.

The turf industry is an industry which was identified by the Urban Stormwater Education Program as one with the potential to impact negatively on urban stormwater. Golf courses are a key sector of the turf industry with approximately 450 golf courses in NSW. If managed well, golf courses can provide many environmental benefits such as stripping urban stormwater of contaminants and nutrients and providing native wildlife corridors in congested urban environments. If managed badly however, golf courses can be sources of nutrient and chemical run-off causing pollution of waterways and can lead to the degradation of indigenous flora and fauna habitats.

In 2000 the Australian Golf Course Superintendents Association indicated a desire to educate its members on improving environmental management practices on golf courses. A project was developed with the Association to write an educational reference manual and to conduct a number of training workshops around NSW. The manual and workshops would address the key environmental issues for golf course management such as water management, pesticides and fertiliser management and other related practices.

This education manual is based on a manual developed by the AGCSA and the Queensland Environmental Protection Agency in 2001. It has been adapted for the NSW context by the NSW DECC with the permission of the Queensland Environmental Protection Agency.

The second part of the education project consisted of four training workshops which were conducted in July 2002 at Camden Lakeside Golf and Country Club, Long Reef Golf Club, Nelson Bay Golf Club and Coffs Harbour Golf Club. These training workshops were conducted by the AGCSA and the NSW DECC with input from local councils and industry experts.

The AGCSA and the DECC hope that golf course superintendents and their staff will be able to implement better environmental management practices on their courses as a result of this two-pronged information and training project.

SECTION ONE

The Environmental Principles for Golf Courses

SECTION 1: Establishing the Environmental Principles for Golf Courses

KEY CONCEPTS

The governing bodies of golf and golf course designers have recognised the importance of designing, constructing and managing golf courses in an environmentally sustainable manner. Golf courses can provide significant benefits to the environment if constructed and managed using best management practices. They can also result in water pollution, pesticide spills and the destruction of native vegetation if managed poorly. This chapter outlines the key issues and provides an overview of best environmental management practices.

Golf is growing as a recreational pastime and sport and in certain areas of Australia, golf course resorts are a key feature of tourist locations. In recent years an increasing number of publications (overseas and in Australia) have stressed the importance of good environmental management of golf courses. This chapter provides an overview of best environmental management practices found in some key publications available to golf course superintendents and staff. These practices are detailed in full in the following chapters, which focus on key issues such as water and pesticide management.

Summary of key environmental principles and practices from recent publications

Construction or re-construction of golf courses is the first step to sound environmental management. The document, *Golf Courses — Benefits to the Community and Environment*, produced by the Society of Australian Golf Course Architects highlights ten key benefits of golf courses.

The benefits are:

i. they provide wildlife sanctuaries;
ii. they preserve open space and remnant vegetation in urban environments;
iii. they protect topsoil from degradation;
iv. they protect water resources;
v. they rehabilitate degraded landscapes;
vi. they promote physical and mental well-being;
vii. they promote indigenous flora and fauna;
viii. they improve air quality and moderate temperature;
ix. they utilise and treat water resources such as sewage, stormwater and urban runoff;
x. they beautify the environment and provide community education on environmental issues.

The Environmental Strategy for Australian Golf Courses (1998) identified the key environmental issues from an Australian perspective, provided information, promoted awareness of golf clubs as environmental assets and developed national guidelines for the environmental management of golf courses. Key management practices are outlined in the following one page summary:

ENVIRONMENTAL STRATEGY FOR AUSTRALIAN GOLF COURSES (AGU)

The strategies in this document can be summarised under the following categories:

AIR

- Minimise the use of ozone-depleting substances.

EDUCATION

- Develop links with community and environmental groups to raise the awareness of golf courses.
- Provide environmental training to golf course maintenance staff.

ENERGY

- Carry out energy conservation in buildings, equipment, machinery, vehicles and irrigation systems.

HERITAGE

- Identify and protect heritage items and places.

MANAGEMENT

- Prepare a course-specific environmental management plan.
- Assess the environmental state of the golf course by introducing and developing monitoring programs.

PESTICIDES

- Develop a management plan for the safe use and storage of pesticides.

SOIL

- Assess the environmental state of the golf course through soil monitoring programs.
- Carry out conservation and amelioration of degraded soils.
- Control pollution during construction activities.
- Test and dispose of contaminated soils appropriately.

VEGETATION

- Protect and rehabilitate remnant native vegetation.
- Use local native plant species.

WASTE

- Reduce, reuse and recycle waste.

WATER

- Use water-saving devices and techniques.
- Consider the pollution potential when choosing fertilisers, pesticides, soil ameliorants and irrigation water sources.

WILDLIFE

- Use wildlife-compatible habitat design in roughs and non-play areas to encourage the wildlife corridors concept.
- Create new wildlife habitat areas.

Another resource was developed in the USA by a group of leading golf and environmental organisations. The set of principles (1996) they wrote aim to produce environmental excellence in:

- golf course planning and siting
- design
- construction
- maintenance
- facility operations.

The set of principles is comprehensive and should be read in full if possible. The following key areas are worth highlighting in relation to eco-efficiency principles and practices:

Planning and siting

- Work closely with community groups and regulatory/permitting bodies.
- Undertake a detailed site analysis to determine potential environmental impacts.
- Take environmentally sensitive areas into account.
- Restore or enhance environmentally sensitive areas .
- Avoid unsuitable or sensitive sites (e.g. wetlands, habitats for threatened species, sensitive aquatic habitats)
- Aim to increase and enhance the range of indigenous Australian plants
- Use golf course development as a means of restoring or rehabilitating previously degraded sites.

Design

- Identify existing ecosystems and use these in the overall design.
- Retain native vegetation or replant it where appropriate in non-play areas.
- Use design to emphasise irrigation, drainage and retention systems that provide water conservation, protect water quality and ensure efficient water use.

- Implement water reuse (wastewater) strategies wherever they are economically feasible and environmentally and agronomically acceptable.
- Create buffer zones to protect high-quality surface waters and environmentally sensitive areas.
- Design the course with sustainable maintenance in mind. (The design should incorporate integrated plant management and resource conservation strategies that are environmentally responsible, efficient and cost-effective.)
- Use design to enhance and protect special environmental resource areas.

Construction

- Use qualified and experienced contractors.
- Develop and implement strategies to effectively control sediment, minimise loss of topsoil, protect water resources and reduce disruption to wildlife, plant species and designated environmental resource areas.
- Ensure only VENM (Virgin Excavated Natural Material) is used for fill.
- Schedule construction and turf establishment to allow for the most efficient progress of works.
- Engage a qualified course superintendent/project manager early in the design and construction process to integrate sustainable maintenance practices in the development, maintenance and operation of the course.

Maintenance

- Provide plant protection and nutrition.
- Employ integrated pest management strategies.
- Store and handle pesticides and fertilisers safely according to environmental regulations.
- Use nutrient products (e.g. slow release fertilisers) and practices that reduce the potential for contamination of ground and surface waters.
- Test and monitor soil conditions.
- Allow only trained personnel to apply plant protection chemicals.
- Use facilities to inform golfers about course chemical application.

Water use

- For areas in play, use plant materials that are well adapted to local environmental conditions, can be efficiently managed, and provide the desired playing surface.
- Use naturalised or specialised drought-tolerant plants wherever possible.
- Plan irrigation programs to meet plant water use requirements to avoid over-watering. Introduce technology that provides efficient water use. Inspect systems regularly.
- Use effluent water wherever appropriate (in accordance with the requirements of regulatory and advisory bodies as well as the water supplier).
- Manage water use effectively to prevent unnecessary depletion of local water resources.

Waste management

- If clippings are collected, compost them.
- Dispose of chemical rinsates appropriately and according to regulations.
- Dispose of chemical containers appropriately (i.e. triple rinse, then contact the drumMUSTER program. Ring 6230 6712 or email: drummuster@drummuster.com.au).
- Recycle or dispose of other wastes such as used motor oil, batteries etc according to local regulations.
- Reduce waste by purchasing goods with minimal packaging.

Wildlife management

- Protect and expand habitats of beneficial wildlife species.
- Manage habitats to maintain healthy populations of wildlife and aquatic species.
- Manage species that build up into pest numbers and damage turf areas through non-harmful control methods (e.g. noisemakers, repellents and trapping and removal).

Facility operations

- Use facilities to conduct an environmental assessment in order to develop and implement an overall environmental policy.
- Maintain records to document progress.
- Use facilities to adopt practices and technologies that conserve natural resources including water and energy.
- Develop programs of recycling, reuse and waste reduction.
- Urge facilities to join programs that foster effective environmental management and policies.
- Use facilities proactively to educate golfers, neighbours and the general public about golf course environmental policies and practices.

What golf course management, staff and golfers can do

Those who play golf, as well as superintendents, their staff and club management, have a responsibility to ensure that golf courses are managed sustainably and that they are in keeping with their local environment.

The topics outlined in this chapter could be used by the golf course management, superintendent, staff and golfers to develop a site-specific environmental management strategy and a plan. An environmental management plan (EMP) may be developed with the assistance of an expert consultant. However, by using the expertise of the local community, various government and non-government agencies as well as the golfers, the superintendent and staff can quite readily develop one themselves. As outlined in the *Environmental Strategy for Australian Golf Courses*, an EMP was developed for Toukley Golf Club on the NSW Central Coast, with the assistance of a variety of agencies, including the local community. The development, implementation and on-going modification of an EMP is a useful education tool for both the golf course staff and for the community groups involved. It can improve environmental practices in a relatively cost-efficient and interactive way.

REFERENCES

Centre for Resource Management, The Golf Course Superintendents Association of America. (1996) *The environmental principles for golf courses in the United States*. www.gcsaa.org/

The Australian Golf Union (1998) *Environmental Strategy for Australian Golf Courses* Victoria Australia

The Society of Australian Golf Course Architects, *Golf Courses—Benefits to the Community and Environment.* See: http://www.sagca.org.au/environment.asp

SECTION TWO

Water Management

Contents

SECTION 2:
Water Management

KEY CONCEPTS

- The availability of a good-quality and regular water supply is essential in maintaining high-quality turf surfaces.
- Possibly the single greatest threat to the management of golf courses is the lack of water and the increasing salinity of water supplied.
- As the demand for potable water increases, golf courses will potentially have to use lower-grade water supplies which are high in salts, sodium, nutrients and other contaminants.
- With the increased use of lower-quality water supplies, more intensive management will be required using various water treatment and soil remediation techniques.
- Reclaimed wastewater is an underused resource that can provide a good-quality water source for golf courses.

- Common source water indicators for turf include:
  - total soluble salts (salinity)
  - sodium
  - sodium adsorption ratio (SAR)
  - chloride
  - carbonate
  - bicarbonate
  - boron
  - pH

- Additional reclaimed water indicators include:
  - nutrients (phosphorus, nitrogen and potassium)
  - human pathogens (indicated by thermotolerant coliforms)
  - other contaminants (e.g. trace metal, pesticides)

Before initiating a reuse system it is important to have an understanding of the site conditions, including:

- geology and soils
- topography
- proximity to ground and surface water
- climate, rainfall, runoff and evaporation conditions
- irrigation requirements
- vegetation types.

- High-salinity water can be managed through modified irrigation and soil management practices and the selection of salt-tolerant grasses.

2.1 INTRODUCTION

Water is essential for sustaining and maintaining the quality of life that we are used to in Australia. For most Australians in urban environments, water arrives at the turn of a tap, clean and free of disease. Water is often taken for granted and very little concern is shown for the economic, environmental and social costs associated with its supply.

Under the *Protection of the Environment Operations Act 1997* (POEO) it is an offence to pollute waters (Section 120). It is also an offence to cause or permit water pollution.

'Waters' means the whole or any part of:

- any river, stream, lake, lagoon, swamp, wetlands, unconfined surface water, natural or artificial watercourse, dam or tidal waters (including the sea); or
- any water stored in artificial works, any water in water mains, water pipes or water channels, or any underground or artesian water.

Under POEO it is an offence to willfully or negligently cause a substance to leak, spill or otherwise escape in a manner that harms or is likely to harm the environment. Heavy penalties apply, including up to $1 million for a corporation and $250 000 and 7 years gaol for an individual.

Australia is a dry continent and our water resources are essentially finite. It is fortunate that we are able to supplement our surface catchment areas with millions of litres of subterranean water that has been stored over millions of years.

The major pressures on our waterways have been described as:

- excessive surface and groundwater abstractions;
- loss of riparian vegetation;
- loss of wetlands;
- altered flow regimes resulting from dam and barrage construction and water abstraction;
- increased sediment, nutrient, salt and contaminant (e.g. pesticide) inputs from agricultural and urban developments;
- introduced, translocated and nuisance species;
- hazardous industrial and mining waste discharge; and
- river modification.

Australia is a country that is often subjected to severe drought, which places increasing pressure on the available water. It is necessary to carefully prioritise where water is to be used, whether in households, agriculture, irrigating turf or industry. Acknowledging that the available water is finite, there is a need to utilise alternative sources.

The maintenance of a high-quality turf relies on having access to a constant water source that is of moderate to good quality. The time is approaching where high-quality potable (drinking) water will not be available for turf areas and lower-quality water higher in salts and other contaminants will have to be used. As a consequence of droughts, the cost of potable water and the lack of potable water available for irrigating turf, many golf courses have been forced to use alternative water sources such as reclaimed wastewater and saline bore water. This has increased the emphasis on research toward environmental stress-resistant and water-efficient turfgrasses (Kenna and Horts 1993).

In the long term, to be ecologically and economically sustainable golf courses will have to:

- make do with lower-quality water sources;
- alter management practices;
- treat the water and soils to offset the detrimental effects of salts, bicarbonates and nutrients;
- introduce more water-efficient and salt-tolerant turfgrass species;
- have a greater knowledge of water quality and its impact on soils and plants;
- undergo increased soil, water and plant monitoring; and
- use improved irrigation practices.

2.2 WATER QUALITY CRITERIA

The quality of a water supply is judged by the amount of dissolved and suspended materials present (VIRASC 1980). High quality is generally associated with low amounts of these materials; however, in practice quality must always be considered in relation to the intended use. ANZECC and ARMCANZ (2000) provide guidelines for assessing the quality of water so that it is safe and optimal for irrigation.

Key source water indicators for turf (Harivandi 1997) include the following:

- Salinity – measures the presence of soluable salts in or on soils or in waters. High salinity levels in soils can result in reduced plant productivity.
- Sodium (Na) – contributes to soil salinity and sodicity, and has the potential to result in foliar injury when present in spray irrigation.
- Sodicity or sodium adsorption ratio (Na, Ca, Mg) – to assess potential soil structural or permeability problems.
- Chloride (Cl) – risks relate to foliar injury from spray irrigation, and increased chloride and cadmium uptake by plants.
- Bicarbonate (HCO_3) and carbonate (CO_3) – elevated levels can adversely affect soil structure, crop foliage or irrigation equipment.
- Boron – essential for turf growth but high levels can be toxic.
- pH – indicates potential impacts of acidity or alkalinity of irrigation water (very high or low soil pH affects the availability of nutrients and other elements to plants; is used to assess the potential affects of other parameters at various pH levels; is one surrogate measure of effluent treatment efficiency; and is used to assess potential for corrosion and fouling of irrigation systems).

Additional key reclaimed water indicators include the following:

- Nutrients (phosphorus, nitrogen and potassium) for plant requirements and surface and groundwater protection against nutrient enrichment.
- Human pathogens (indicated by thermotolerant coliforms) for public health protection.

Monitoring a sub-set of the above indicators and any additional risk factors may be required for assessing potential impacts on surface and ground waters (e.g. BOD, thermotolerant coliforms, plant-available nutrients) and additional indicators in soils or plants for sound agronomic practice (e.g. turf grass nutrient status) or potential groundwater pollution (e.g. phosphorus sorption capacity, nitrates).

Key indicators from above are addressed in relation to turf management in the following sections.

2.2.1 Salinity

The soluble salt level is a key indicator of the quality of bore, dam, recycled, or runoff water used for irrigation. High-salinity water causes an increase in soil salts and as soil salinity increases it becomes more difficult for plants to extract water from the soil. This is due to an increase in the osmotic pressure of the soil water, that is the salts 'hold' the water so strongly that plants cannot remove it and therefore appear to be under drought stress even when adequate moisture is present.

Table 2.1 outlines the different classes for irrigation water based on the soluble salt content. As a general rule, salts exceeding 1000 mg/L (about 1.5 dS/m) severely limit water use on turf; however, this is dependent on grass species and variety, soil type, thatch level and irrigation and soil management.

Salt-tolerant grasses growing on well-drained soils that are readily leached of salts can be irrigated with saline water with up to 2000 mg/L (about 3 dS/m) total salts. Excessive and frequent applications of water are required so that leaching occurs and the soil is prevented from drying out excessively.

ANZECC and ARMCANZ (2000) provides useful guidance on managing saline water used for irrigation. See: http://www.ea.gov.au/water/quality/nwqms/index.html#quality

2.2.2 Sodium

High concentrations of sodium, relative to calcium and magnesium, in irrigation water can adversely affect plant growth and soil structure and can lead to reduced permeability, aeration, infiltration, leaching and soil workability. The degree to which soil dispersion occurs is also dependent on the soil's clay content and mineralogy, pH, Ca/Mg ratio, EC, organic matter content and the presence of iron and aluminium oxides (ANZECC and ARMCANZ 2000). The most commonly used method to evaluate the potential for saline irrigation water to cause soil problems is to calculate the sodium adsorption ratio. Soil sodicity refers to the amount of exchangeable sodium cations relative to other cations in the soil and is expressed in terms of exchangeable sodium percentage (ESP).

Australian soil scientists have concluded that soils with an ESP of greater than 5 are at risk of showing the adverse structural impacts associated with sodicity. Effluent with an SAR of greater than 6 is likely to raise ESP in non sodic soils, whereas effluent with a SAR of less than 3 may lower ESP in sodic soils. Prior to irrigating with saline water it may be beneficial to determine the existing ESP in the soil and conduct ongoing soil monitoring of ESP where SAR of irrigation water is elevated.

The sodium adsorption ratio (SAR) is defined by the equation:

$$SAR = Na^{+} / \sqrt{}\ [(Ca^{++} + Mg^{+}) / 2]$$

where Na, Ca and Mg represent the concentrations in milli-equivalents per litre of the respective ions. Tables 2.2 and 2.3 show the sodium hazard based on SAR and related to clay type.

On some clay soils or soils with a low Cation Exchange Capacity (CEC), an SAR greater than 6-8 gives cause for concern and efforts have to be made to minimise the breakdown in soil structure. On sandy soils where permeability is less of a problem, the cation exchange sites become saturated with Na at the expense of Ca, K and Mg and sodium is taken up by the plant in preference to these other cations. Sodium accumulation in the plant can then reach toxic concentrations, resulting in a loss of turf vigour, low recovery potential, lower tolerance to heat stress, reduced tolerance to pests and diseases, and potential death of sodium-sensitive plant species. Fortunately, most turfgrass species have moderate to good tolerance to sodium and while there may be a reduction in vigour, death of the plant is unlikely.

Calcium must be applied to counteract the effects of high-sodium waters, most often in the form of gypsum ($CaSO_4$). Gypsum can be applied directly to the turf, or it can be applied through the irrigation system. In situations where the sodium content of the water is very high and there is a need to apply large amounts of gypsum, regular small applications applied through the irrigation system are more convenient and effective than large, irregular applications to the turf.

2.2.3 Bicarbonate and carbonate

Permeability problems are also related to the carbonate (CO_3) and bicarbonate (HCO_3) content in the irrigation water and this is not considered in the SAR calculation. When drying of the soil occurs, part of the CO_3 and HCO_3 precipitates as Ca-$MgCO_3$, therefore removing Ca and Mg from the soil water and increasing the relative proportion of sodium. The presence of high concentrations of CO_3 and HCO_3 can cause nutritional disturbances, such as reducing the availability of calcium and the uptake of iron. The effect of CO_3-HCO_3 on soil permeability can be calculated by the Residual Sodium Carbonate (RSC) method or by using a modified SAR equation (adjusted SAR) (Carrow and Duncan 1998). The adjusted SAR includes the influence of carbonate and bicarbonate ions and their effects on calcium and magnesium. Calculating the RSC is the most convenient method of determining the bicarbonate/carbonate hazard, which is as follows:

$$RSC = (CO_3) + (HCO_3) - (Ca + Mg)$$

where CO_3, HCO_3, Ca and Mg are in milli-equivalents per litre (meq/L).
Table 2.4 lists the potential problems associated with bicarbonate and carbonate.

High-bicarbonate waters can be treated by acidification of the irrigation water to remove the excess bicarbonate (Carrow et al. 2000). Acid treatment systems available in Australia inject acid into the irrigation mainline, the quantity of acid being determined by the volume of water applied and the pH.

CASE STUDY: Acid Injection

At one Australian golf course an acid injection system was installed four years ago. The acid injection system provided several advantages:

- no mains water was required
- fungicide usage was reduced
- greens retained complete turf cover
- golfer satisfaction increased.

The costs and benefits are as follows:

acid injection unit	$35,000
acid (annual cost)	$20,000
savings in mains water	$40,000
savings in fungicides	$5,000 (approx.)
payback period	1.4–2 years

2.2.4 Chloride

Sodium and chloride are the most damaging ions, chloride being particularly toxic (see table 2.5). Plants accumulate chloride to the exclusion of calcium, magnesium and potassium, causing nutritional disturbances. In addition to being taken up by the plant, chloride will cause direct injury to the plant as water dries on the leaf, particularly if irrigation is undertaken during the heat of the day. However, there is significant variation in plant tolerance to chloride, enabling the selection of more tolerant plants to be used under saline conditions. Table 2.5 shows the levels of various ions that can be associated with soluble salts and their acceptable levels.

Table 2.1: Salinity class of irrigation waters

Salinity hazard class	Comments	EC_{iw} (dS/cm)
Low	Low salinity hazard, no detrimental effects on plants or soil build-up are expected.	<0.75
Medium	Sensitive plants may show salt stress, moderate leaching prevents soil salt accumulation.	0.75–1.5
High	Salinity will adversely affect most plants. Requires selection of salt-tolerant plants, careful irrigation, good drainage and leaching.	1.5–3
Very high	Generally unacceptable except for very salt-tolerant plants, excellent drainage, frequent leaching and intensive management.	>3

Table 2.2: Sodium hazard of irrigation waters

Sodium hazard classification	SAR or adj SAR*	Comments
Low	<10	Can be used on most soils without structure deterioration. Salt-sensitive plants may be affected.
Medium	10–18	Appreciable Na hazard on fine-textured soils with high CEC. Best used on coarse-textured soils with good drainage.
High	1826	Harmful levels of Na accumulation on most soils. Will require intensive management—amendments, drainage and leaching.
Very high	>26	Generally not suitable for irrigation. Requires intensive management.
***Use SAR when HCO_3 is < 120 mg/L and CO_3 is < 15 mg/L. Use adj SAR when HCO_3 and CO_3 are higher.**		

Table 2.3: Sodium hazard of irrigation waters based on clay type classification*

Sodium hazard classification	SAR or adj SAR*	Clay type	Comments on Na hazard
None	<6 <8 <16	Montmorillonite Illite Kaolinite	Generally no Na hazard unless EC_w is very low
Possible	6–9 8–16 16–24	Montmorillonite Illite Kaolinite	Possible problem unless a Ca source and some leaching are used
Probable	>9 >16 >24	Montmorillonite Illite Kaolinite	Requires intensive corrective measures to use

** Ayers and Westcot (1985)*

Table 2.4: Sodium hazard (permeability) of irrigation water based on residual sodium carbonate

RSC value (meq/L)	Na hazard
<0 (i.e. negative)	None. Ca and Mg will not be precipitated as carbonates from irrigation water; they remain active to prevent Na accumulation on CEC sites.
0–1.25 Low.	Some removal of Ca and Mg from irrigation water.
1.25–2.50 Medium.	Appreciable removal of Ca and Mg from irrigation water.
>2.50 High.	High. All or most of Ca and Mg removed as carbonate precipitates leaving Na to accumulate. How rapidly Na build-up occurs depends on Na content of the water.

Tables 2.1, 2.2 and 2.4 adapted from: Carrow and Duncan *(1998)*

Table 2.5: Specific ion toxicity

Parameter	No problems	Increasing problems	Severe problems
Chloride			
Foliar absorption (mg/L)	<106	>106	
Root absorption (mg/L)	<142	142–355	>355
Sodium			
Foliar absorption (mg/L)	<69	>69	
Root absorption (SAR)	<3	3–9	>9
Boron	<1	1–2	>2

Reference: Ayers and Westcot *1976*

2.3 RECLAIMED WASTEWATER

KEY CONCEPTS

- Effluent is an excellent source of water if it is of satisfactory quality for the intended purpose.
- The salts, nutrients etc. in effluent can be beneficial, but in excess they pose a significant environmental risk.
- Reuse of effluent must be sustainable in the long term. Excessive concentrations of nutrients, salts, heavy metals and other contaminants can cause rapid and severe deterioration of soils, turf quality and water bodies.
- With careful planning, good understanding of the interactions between effluent and the site, good water and nutrient management and an appropriate monitoring program, effluent can be a useful resource that saves fresh water and reduces fertiliser use.

Reclaimed wastewater, which is primarily treated sewage effluent, is increasingly being used to irrigate turf. A number of detailed reports (Lang et al. 1977; GHD 1977; NSW Task Force on Reclaimed Water 1982) have investigated and described the feasibility of reusing treated sewage effluent. A Department of Resources and Energy report (1983) stated that in Australia the total amount of treated sewage was about 1300 gigalitres/annum, of which 56 gigalitres/annum (4.4%) is reused in irrigation. Treated wastewater is an important water resource for irrigation purposes and in the future it may be the only source of supplemental water available for turf culture.

In regions serviced by Sydney Water, annual usage of recycled water has settled at an average of approximately 27 megalitres per day over the past four years. Recycling within sewage treatment plants (STPs) accounted for 89% of all recycling, irrigation for 10% and industrial recycling for 1%. The present level is about 2% of daily water consumption (Sydney Water 2001).

As demands on our water supplies for domestic consumption increase, less water becomes available for irrigation purposes. However, the increase in urban development brings not only a greater demand for potable waters but also generation of more wastewater. The treatment of this wastewater and its disposal have become significant environmental issues. In particular, the disposal or reuse of wastewater must be done in an ecologically sustainable manner. Wastewater can contain a range of contaminants including salts, nutrients, heavy metals, viruses and bacteria that can limit the reuse options. The use of wastewater that has a heavy contaminant load can have implications for human health, cause soil degradation and result in uncontrolled discharge of pollutants to surface and groundwaters. The other important component of the sustainability equation is maintaining the playing quality of the turf area.

The reuse of wastewater will, in the future, be an integral part of ecologically sustainable development and integrated catchment management philosophies concerning water quality. There is now strong encouragement to reuse treated wastewater for irrigation purposes in order to protect the quality of surface waters.

In most states, environment protection policies demand that wastewater no longer be discharged to surface waters and that it be reused. The general philosophy and, in some cases, legislation demand there be no discharge of wastewater to waterways by early in the new millennium. As a consequence, numerous reuse schemes are being established around Australia to use wastewater for turf irrigation.

The reuse of wastewater has a strong community appeal and it seems to be the right thing to do. However, if a reuse scheme is to be sustainable for a long period—and most authorities define this as at least 50 years—then much investigation is required before the scheme is implemented. Once the scheme is implemented, it must then be monitored by the water authority, environmental regulators and the golf course to ensure that it is sustainable and does not present an environmental or public health risk

2.3.1 Guidelines for the reuse of reclaimed wastewater

Most of the state authorities responsible for the reuse of wastewater, such as the NSW Department of Environment and Climate Change (DECC) and the various state health authorities, have in conjunction with Departments of Agriculture and water authorities produced guidelines for wastewater reuse. While State guidelines vary, the underlying philosophies are similar and most use the ANZECC and ARMCANZ (2000) water quality guidelines and for sewerage effluent, the ANZECC, ARMCANZ and NHMRC (2000): *Guidelines for sewerage systems – use of reclaimed water* as their base documents. In NSW, the reuse of treated wastewater is covered in the *Draft Environmental Guidelines for Industry – The Utilisation of Treated Effluent by Irrigation* (NSW DECC 1995). The following information provides a general overview of this document from a turf management perspective.

2.3.2 NSW guidelines for use of effluent by irrigation

The DECC's Draft Environmental Guideline *The Utilisation of Treated Effluent by Irrigation* (NSW DECC 1995), is the principal reference and should always be consulted for detailed guidance on irrigating effluent.

The DECC guideline is educational and advisory in nature and can be described as outcome- or performance-based, encouraging best management practices. This means that the guideline describes environmental outcomes (which may be required by legislation or government policy) and provides information on some of the acceptable approaches that may be used to achieve those outcomes. This gives the user the flexibility to develop other approaches specific to their site that meet the environmental outcomes described in the guideline. The guideline is not a mandatory or regulatory tool but is designed to assist the user to achieve a sustainable effluent irrigation scheme. The topics that the guideline includes are described below.

Scope of the guidelines

The guideline provides information for planners, designers, installers and operators of effluent irrigation systems, with the aims of:

- encouraging the beneficial use of effluents and providing guidance as to how this might be accomplished in an ecologically sustainable manner;
- providing guidance for the planning, design, operation and monitoring of effluent irrigation systems in order to minimise risks to public health, the environment and agricultural resources; and
- outlining the statutory requirements that may be needed for an effluent irrigation system in NSW.

The document is an environmental guideline, it is not a design and operations manual. Technical and scientific problems associated with the use of effluent can be complex and often require the integrated efforts of several disciplines in science and engineering. Accordingly, designers and operators might need to seek advice from specialist consultants and from government authorities such as NSW Agriculture, the Department of Planning, NSW Health and Workcover NSW.

Environmental performance objectives

The DECC has established the following environmental performance objectives for using effluent by irrigation.

Resource use: *Potential resources in effluent, such as water, plant nutrients and organic matter, should be identified, and agronomic systems developed and implemented for their effective use.*

Prevention of public health risks: *The effluent irrigation scheme should be sited, designed, constructed and operated so as not to compromise public health. In this regard, special consideration should be given to the provision of barriers that prevent human exposure to pathogens and contaminants.*

Protection of surface waters: *Effluent irrigation systems should be located, designed, constructed and operated so that surface waters do not become contaminated by any flow from irrigation areas, including effluent, rainfall run-off, contaminated sub-surface flows or contaminated groundwater.*

Protection of groundwater: *Effluent irrigation areas and systems should be located, designed, constructed and operated so that the current or future beneficial uses of groundwater do not diminish as a result of contamination by the effluent or run-off from the irrigation scheme or changing water tables.*

Protection of lands: *An effluent irrigation system should be ecologically sustainable. In particular, it should maintain or improve the capacity of the land to grow plants, and should result in no deterioration of land quality through soil structure degradation, salinisation, waterlogging, chemical contamination or soil erosion.*

Community amenity: *The effluent irrigation system should be located, designed, constructed and operated to avoid unreasonable interference with any commercial activity or the comfortable enjoyment of life and property off-site, and where possible to add to the amenity. In this regard, special consideration should be given to odour, dust, insects and noise.*

Protection of plant and animal health: *Design and management of effluent irrigation systems should not compromise the health and productivity of plants, domestic animals, wildlife and the aquatic ecosystem. Risk management procedures should avoid or manage the impacts of pathogenic micro-organisms, biologically active chemicals, nutrients and oxygen depleting substances.*

Planning and approvals

Users of effluent irrigation may have specific statutory obligations under health, environmental, agricultural and/or food legislation in NSW and these may be a condition of land development. In addition, wastewater treatment plant owners, operators and end-users may be liable under common law and under the *Trade Practices Act* for the use of effluent that causes harm. Proposals for an effluent irrigation system should be discussed at the early planning stage with the relevant regulatory or advisory authorities which may include the local council, NSW DECC, NSW Health, NSW Agriculture, Department of Planning and the WorkCover NSW.

Environment Protection Licences

Specific activities and premises are required to be licensed under the *Protection of the Environment Operations Act 1997* (the POEO Act); however, an environment protection licence is not likely to be required for effluent irrigation schemes operating in accordance with the DECC guideline.

Scheduled activities

Schedule 1 of the POEO Act is the 'Schedule of EPA-licensed activities.' A licence is always required for Scheduled activities. Whenever effluent irrigation is ancillary to a Scheduled activity, the licence associated with the scheduled activity may also include conditions relating to the effluent irrigation.

Under the POEO Act, DECC is the relevant authority for an activity whenever:

- the activity is listed on Schedule 1 of the POEO Act;
- a licence to control water pollution from the activity has been granted; or
- a public authority is carrying out the activity or is occupying the premises where the activity occurs.

Effluent irrigation is not specifically listed on Schedule 1, therefore it does not generally have to be licensed.

Non-scheduled activities

Non-scheduled activities are any activities other than those listed in the 'Schedule of EPA-licensed activities.' The POEO Act does not generally require non-scheduled activities, which includes effluent irrigation, to be licensed. Operators of effluent irrigation schemes should be able to manage their effluent to avoid pollution of water.

Golf courses

Golf course construction and operation is a non-scheduled activity and therefore does not generally require an environment protection licence. The local council will be the appropriate regulatory authority for golf courses.

Site assessment

Where reclaimed water is to be used as a source of irrigation water it is very important that a detailed analysis and site investigation are undertaken as part of the planning process. Site assessments for golf courses must look in detail at all greens, tees and fairways, soil types and all other areas to be irrigated with effluent.

ESSENTIAL SITE ASSESSMENT CRITERIA

- Soil types and soil limitations for irrigation of effluent (including phosphorus sorption capacity, exchangeable sodium percentage, soil salinity, depth to seasonal high water table, depth to bedrock or hardpan, saturated hydraulic conductivity; available water capacity, soil pH (CaCl2), effective cation exchange capacity, emerson aggregate test).
- Limiting site characteristics (including drainage, climate, proximity and sensitivity of ground and surface waters, topography, geology of the site; proximity to dwellings or other sensitive receptors, flooding potential).
- Grass species.
- Irrigation requirements and methods.
- Nutrient loads.
- Ability of the site to cope with extra demands because of the effluent, e.g. extra growth, runoff containment.
- Proximity to dwellings.

Reclaimed water treatment

Effluent may include water from industrial sources, stormwater runoff and sewage. The quality of the effluent depends on its source and level of treatment. For reclaimed water from sewerage systems, effluent quality also depends on the catchment and industries serviced. Treatment must be such that it protects the beneficial uses of soil, ground and surface waters from polluted runoff and protects public health from toxicants and micro-organisms.

A priority performance objective for effluent reuse is protection of human health. In general, the better the treatment and the greater the disinfection, the fewer micro-organisms there will be and therefore there are fewer restrictions to site access and management. For example, tertiary or advanced treatment of sewerage wastewater will produce an effluent that is very low in biological oxygen demand (BOD), suspended solids (SS), coliform bacteria and viruses and the wastewater can be used for food crops or aquaculture with fewer controls on human access to the irrigated area.

For irrigation of reclaimed water from sewerage systems, public health requirements are based on national *Guidelines for Sewage Systems — Reclaimed Water* (ARMCANZ, ANZECC & NHMRC 2000). This national guideline outlines general treatment, disinfection and irrigation requirements, however, in NSW the NSW DECC or NSW Health may adopt more stringent requirements on a site-specific basis.

NSW Health should be consulted in regard to the level of treatment of effluent to be achieved when public health could be at risk through contact with irrigated effluent.

Golf courses

For golf courses, the relevant end-use category in the national sewerage reclaimed water guidelines is: 'URBAN (NON POTABLE) — Municipal with either controlled or uncontrolled public access'.

Nutrients, salts and heavy metals are recognised as important constituents of wastewater and must be accounted for in determining the sustainability of a reuse site.

Reclaimed water quality for irrigating turf

The quality of irrigation waters has already been outlined in Section 2.2. The DECC effluent irrigation guideline provides a detailed description of the key constituents of reclaimed wastewater and how effluent quality should be considered in the design and operation of an irrigation system. Summary information on key effluent constituents with emphasis on turf irrigation is provided below.

- **Nitrogen:** In wastewater nitrogen levels can be very high and the main impact of this will be on grass growth. Every time the turf is irrigated it is fertilised with a soluble source of nitrogen that is readily taken up by the plant. Uncontrolled and lush growth can occur, resulting in a soft, thatchy and disease-prone turf. Nitrogen that enters waterways can also stimulate growth of nuisance plants and weeds and algae.

- **Phosphorus:** Phosphorus is another important element and applications in excess of what the soil can absorb and the vegetation will take up can be leached into ground and surface waters. Excess phosphorus in waterways is a prime cause of algae growth.

- **Heavy metals:** Heavy metals such as zinc, iron, copper, nickel, lead, chromium and cadmium occur in recycled water. Iron, zinc and copper are essential for healthy turf but in excessive amounts these elements are toxic. Heavy metals in recycled water can be a problem where the main source of effluent is of industrial origin; however, recycled water that is mainly of domestic origin has a low heavy metal input and is unlikely to be toxic to turf. The ANZECC and ARMCANZ (2000) guidelines for irrigation water quality and Harivandi et al. (1997) have published comprehensive lists of heavy metals and the recommended concentrations.

- **Boron:** Boron occurs naturally in some soils and groundwater as well as in recycled water. Boron is used in detergents and soaps and most treated effluent contains 0.5–1.0 mg/L of boron. Boron is essential to turf growth but levels greater than 2.0 mg/L can be toxic. The effects of boron depend on plant species tolerance and soil conditions. Well-drained soils that are readily leached generally do not accumulate boron because it is a mobile element and is easily leached through the soil. In general, recycled water of domestic origin does not contain toxic levels of boron.

- **Human pathogens:** When dealing with treated wastewater, health considerations must be taken into account. Wastewaters (such as those from sewerage systems) can contain a wide variety of potentially infectious microorganisms. Thermotolerant coliforms are the most commonly used indicator of pathogens.

All states have public health requirements governing the microbiological quality and use of recycled water. These requirements are generally based on the ANZECC, ARMCANZ and NHMRC (2000) reclaimed water guidelines and are designed to provide assistance to authorities, users and the general public.

- **Other contaminants:** Wastewater used for turf irrigation can come from a range of sources and knowledge of what takes place at the source will provide an indication of possible toxic elements, for example:
  - citrus processing — various oils and acids;
  - sewerage treatment — e.g. agricultural and industrial chemicals;
  - petroleum processing — hydrocarbon residues; and
  - wool scouring — sodium and bicarbonate.

Design considerations

The design of an effluent irrigation scheme needs to take into consideration a range of factors including: site limitations, plant selection, volumes of water and levels of pollutants in effluent, irrigation methods and scheduling, land area available for irrigation, storage requirements of effluent; stormwater runoff controls, and buffer distances to sensitive receptors such as waterways.

Water and nutrient budgets

When planning and designing a scheme to use reclaimed wastewater or where it is already in use, it is very important to estimate the annual water requirements and nutrient load as this will have a significant effect on the fertiliser program, soil management and the health and quality of the turf. The calculation of the irrigation requirement is detailed in section 2.6.

The nutrient content is an important economic as well as environmental consideration (Harivandi et al. 1997). Even if the concentration of nutrients is relatively low, because they are applied on a regular basis, the nutrients are efficiently used by the turfgrass.

CALCULATING NITROGEN LOADINGS

Average total nitrogen in the wastewater	= 30 mg/L (0.00003 kg/L)
Evapotranspiration (ET) per irrigation season	= 350 mm
Volume of water applied per 100 m² per season	= 35 000 L
Total nitrogen applied per 100 m² per season	= 35 000 L × 0.00003 kg
Total nitrogen applied per 110 m² per season	= 1.05 kg/100 m²

If the annual nitrogen requirement is 3kg/100m², then the reclaimed wastewater will provide about 30% of the annual requirement.

CALCULATING PHOSPHORUS LOADINGS

Average total phosphorus in the wastewater	= 5–10 mg/L (0.000005–0.00001 kg/L)
Evapotranspiration (ET) per irrigation season	= 350 mm
Volume of water applied per 100 m² per season	= 35 000 L
Total phosphorus applied per 100 m² per season	= 35 000 L × 0.000005 kg (0.00001 kg)
Total phosphorus applied per 100 m² per season	= 0.175–0.35 kg/100 m².

If the annual phosphorus requirement is 0.5–0.8 kg/100 m², then the reclaimed wastewater will provide up to 70% of the annual requirement.

The above examples are for a relatively low ET requirement. If the water demand or usage were 1200 mm (120 000 L), then the nitrogen load would be 3.6 kg/100 m² and the phosphorus 0.6–1.2 kg/100 m². In this scenario, the annual nitrogen requirement is provided by the wastewater, as is all of the phosphorus.

The above examples assume that the irrigation season is over the full 12 months; however, this is not the case in all areas of New South Wales where the climate is more seasonal, with periods when no supplementary water is required. It is important to realise that there is little or no carryover of nitrogen in sandy soils and while the applied nitrogen meets the annual requirements it may in fact be applied over a shorter time period. This can result in excessive, soft growth.

In assessing the suitability of wastewater for irrigating turf, long-term analytical data is required, as the quality of wastewater can change during the year: e.g. in summer the salts often increase. Monthly water quality data, over several years, will give a good indication of the possible changes. Unfortunately, many wastewater treatment plants, in particular those in rural areas, often only have minimal information available.

Essential data required for assessing reclaimed water quality:

pH	Electrical conductivity
Calcium	Magnesium
NH_3-N	Total phosphorus
NO_2-N	Boron
NO_3-N	Potassium
Bicarbonate	Heavy metals
Sodium	Chloride

2.3.3 Site evaluation and monitoring

In evaluating the feasibility of using wastewater, it is important to determine whether or not the system can cope with the potential nutrient and salt loads and whether a long-term, sustainable turf system can be maintained.

There is no point in establishing a recycling system because it seems like a good thing to do if in the long term it is going to result in site degradation. *The Utilisation of Treated Effluent by Irrigation (NSW DECC 2004)* describes the procedure for establishing reclaimed water irrigation system.

Procedure for establishing an effluent irrigation system

The following is a suggested checklist of procedures to be followed when setting up an effluent irrigation system:

Planning:

- Discuss the proposal with the relevant DECC regional office and other appropriate authorities.
- Assess effluent quality .

Site selection:

- Select an appropriate site and conduct site assessment
- Any site assessment must look in detail at all greens, tees and fairways and determine the following conditions

ESSENTIAL SITE ASSESSMENT CRITERIA

- Soil types
- Drainage
- Phosphorus retention
- Proximity and quality of ground and surface waters
- Topography
- Geology of the site
- Irrigation requirements
- Nutrient loads
- Ability of the site to cope with extra demands because of the wastewater e.g. extra growth, runoff containment
- Proximity to dwellings

Design:

- Determine the water balance for the irrigation system
- Establish the minimum land area requirements based on limiting loading rates (hydraulic, nutrient, organic and salt)
- Calculate the minimum wet weather storage capacity requirements for the irrigation system
- Define the operational processes to be used in effluent irrigation and management

Statutory approvals:

- Comply with the requirements of the local council, NSW Health, DECC and other authorities in the planning and design stages where appropriate

Installation:

- Install system in accordance with the conditions of Pollution Control Approval
- Once construction is completed, forward a Certificate of Compliance to the DECC indicating that installation has been in accordance with the conditions of approval

Operation and maintenance:

- Operate the system in accordance with best management practices.

On-going monitoring

An annual review of the management plan and monitoring results may be required as a condition of licence and this may be in the form of an annual Environmental Management Report. These procedures enable the operator and the DECC to assess the on-going performance of the irrigation scheme.

Sampling may be required on the following:

- Soils (surface and subsoils down to 2 m) from the irrigation areas;
- Effluent
- Groundwaters and surface waters
- Crops/plants

The samples may need to be analysed for the following constituents, where appropriate:

- Soils: Structure, profile features, cation exchange capacity, electrical conductivity, N and P (total and available), P sorption capacity, organic matter, chloride, and pH.
- Wastewater, and water samples: BOD, N and P (Total and Available), salinity indicators (electrical conductivity, Na, Ca, K, Mg and SAR), exchangeable cations, chloride, chemical contaminants, and TDS.
- Additionally, the water table height should be measured.

Sampling may be necessary where some trace contaminants had previously been identified in the system. Plant analysis also provides the opportunity to fine tune the nutrient budget since it provides quite precise information on nutrient uptake by the vegetation. The frequency of sampling would vary according to the parameter being measured.

Once the site assessment is completed and a reuse program implemented, it is then necessary to initiate a monitoring program. The site assessment will identify key areas that can be used as indicators and include monitoring.

KEY MONITORING POINTS FOR GOLF COURSES

- Surface and groundwater
- Each of the major soil types
- Representative greens, tees and fairways

The monitoring will include water and soil analysis; water use; weather data and records of any significant changes in turf conditions (e.g. pests, weeds and disease, soft growth etc).

Table 2.6: Soil monitoring on wastewater reuse sites*

Parameters	Frequency
pH, EC and salinity, sodium, calcium, magnesium, available phosphorus, total phosphorus, potassium	End of first irrigation season and immediately prior to the next season. A total of 4 samplings over the first 2 years and annually thereafter
Copper, iron, manganese and zinc	Once a year

**Note: Also refer to NSW DECC guidelines for use of effluent by irrigation.*

Table 2.7: Surface water, watertable and bore water monitoring on wastewater reuse

Parameters	Frequency
pH, EC, salinity, bicarbonate, carbonate, sodium, calcium, magnesium, chloride, total phosphorus, total nitrogen, TKN, nitrate and nitrite	6-monthly pre- and post-irrigation season

**Note: Also refer to NSW DECC guidelines for use of effluent by irrigation.*

Where reclaimed water is to be used as a source of irrigation water it is very important that a detailed analysis and site investigation are undertaken as part of the planning process. The following is a basic checklist of tasks that need to be undertaken.

Table 2.8: Checklist for reclaimed water reuse on turf

Task	Done
1. Make contact with the supplier of the reclaimed water (eg. sewerage authority, local council and sewage treatment plant).	
2. Make early contact with the appropriate regulatory agencies (in particular the local council, DECC, NSW Health, the Department of Planning) for approval and other key agencies for advisory information (NSW Agriculture).	
3. Obtain detailed analyses data of the reclaimed water source (long-term data required.	
Data required: • pH and EC	
• Nitrogen	
• Phosphorus	
• Potassium	
• Sodium	
• Calcium	
• Magnesium	
• Sodium Adsorption Ratio	
• Carbonate	
• Bicarbonate	
• Chloride • [+ Cl_2 residual or equivalent pathogen reduction, when required, eg uncontrolled public access]	
• Sulfate	
• Boron	
• Heavy metals and other contaminants (depends on water source)	
• **Biological parameters** - Biological oxygen demand (BOD) - Thermotolerant coliforms - Suspended solids (SS)	
4. Undertake detailed site assessment. The interactions between effluent quality and site/soil characteristics should be considered	
5. Determine uses and restrictions based on analysis of soil and wastewater	
6. Undertake detailed site assessment	
7. Prepare an environmental management plan.	
8. Undertake cost analysis of project including:	
• upgrade to irrigation and water supply system	
• on-site water storage	
• on-site water treatment (e.g. acid or gypsum injection)	
• increased maintenance costs including: - mowing - use of growth retardants - modified working hours - soil amendments (e.g. gypsum) - increased turf renovations	

2.4 TURFGRASS TOLERANCE TO SALINITY

The future for irrigating turf may rely on the use of moderate- to high-salinity water and, in order to ensure that the turf system is sustainable, will rely on the use of salt-tolerant grasses and an improved knowledge of the effects of salinity on turfgrasses.

High levels of soluble salts in the turf rootzone are detrimental to most turfgrasses. Excess soluble salts can affect growth by osmotic inhibition of water uptake (physiological drought) by the specific ions (Harivandi et al. 1992). Salinity affects different species in different ways and the effects can vary according to the age of the plant: salinity effects are generally greater at germination and planting (when vegetative material is used) than in the mature plant. Salinity tolerance in turfgrasses is related to the plants' ability to reduce NaCl uptake.

A number of studies to investigate salt tolerance in turfgrasses and the mechanisms affecting salt tolerance have been undertaken. Younger et al. (1967) observed significant variation in the salt tolerance of creeping bentgrass (*Agrostis* spp.) varieties. The main effect of high salinity was the reduction in top growth; the old variety 'Seaside' had the highest salt tolerance and 'Penncross' the lowest. It was noted that 'Seaside' had high variation between individual plants and Engelke (pers. comm.) has selected new varieties (e.g. 'Mariner') with improved salt tolerance and turf quality based on this variation. McCarty and Dudeck (1993) reported that when germinating bentgrasses in high-salt solutions, 'Streaker' red top and 'Seaside' creeping bentgrass were the most salt-tolerant. 'Kingston' velvet, 'Exeter' colonial and 'Highland' colonial had intermediate tolerance while 'Pennlinks', 'Penncross' and 'Penneagle' creeping bentgrass were the most salt-sensitive. Marcum (2000) has studied the salt tolerance in the modern bentgrass varieties. He tested 35 bentgrass cultivars, with increasing salinity concentrations from 1 decisiemans/metre/day up to 8 decisiemans/metre/day at which time data was collected. The most salt tolerant cultivars were Mariner, Seaside II, Grand Prix, Seaside, 18th Green and Century. The least tolerant cultivars suffered complete death after ten weeks exposure and they included Avalon (velvet bent) Ambrosia (colonial bent) as well as Regent, Putter, Penncross and Penn G-6.

Dudeck and Peacock (1993) carried out a study on warm season grasses and demonstrated that 'Emerald' zoysiagrass (*Zoysia* spp.), FSP-3 Seashore paspalum (*Paspalum distichum*) and 'Tifway' couchgrass (*Cynodon dactylon* × *C. transvaalensis*) were the most salt-tolerant. 'Floralawn' St Augustinegrass (*Stenotaphrum secundatum*), 'Tifway II' couchgrass (*Cynodon dactylon* × *C. transvaalensis*) and 'FSP-1' Seashore paspalum had intermediate salt tolerance while Centipedegrass (*Eremochloa ophiuroides*) and Bahiagrass (*Paspalum notatum*) were very salt-sensitive. Dudeck and Peacock (1993) also demonstrated that as salinity increased, plant K levels decrease and to a lesser degree there is a decrease in Ca, Mg and P.

Duncan and Carrow (2000) have demonstrated that some selections of Seashore paspalum can tolerate undiluted seawater under the correct management regimes. Seawater has an EC of 54 dS/m (34 560 mg/L) and these new salt-tolerant varieties provide an opportunity to use very brackish sources of water though a high level of management is required.

Salinity effects on turfgrass growth have been summarised by Harivandi et. al. (1992) as:

- reduced water uptake due to osmotic stress;
- reduced nutrient uptake — for example, K may be depressed by absorption of Na;
- root biomass may increase to improve water-absorbing ability; and
- Na and Cl reduce growth by interfering with photosynthesis.

Harivandi et al. (1992) have also listed the common turfgrasses and their estimated salt tolerance (Table 2.9).

2.5 MANAGING HIGH SALINITY WATER

ANZECC and ARMCANZ (2000) Vol. 3 Primary Industries, provides guidance on water quality for irrigation. The future management of golf courses may be dependent on the use of lower-quality and higher-salinity water. While the use of salt-tolerant plant species and varieties may increase the viability of using high-salinity water, it is also essential that the golf course manager has a good understanding of complete soil/turf/drainage system to ensure long-term sustainability.

If water of high salinity is the only available water supply, several management techniques can be used to minimise salt damage. These are described below:

- Establish salt-tolerant species and varieties of turfgrasses. Establishment will most likely have to be done using a freshwater source
- Construct the greens and tees using high drainage rate sands that meet the USGA specification (1993) for greens construction and include a subsoil drainage system to ensure that leaching of salts occurs.
- Ensure that irrigations are sufficient to leach salts out of the rootzone and prevent accumulation but do not leach pollutants into groundwater. The amount of water required for leaching, when rainfall is not sufficient for leaching, can be calculated:

$$\text{Leaching requirement} = \frac{EC_{iw}}{EC_{dw}}$$

  where EC_{iw} is the electrical conductivity of the irrigation water and EC_{dw} is the electrical conductivity of the drainage water (VIRASC 1980). One method of calculating the leaching requirement is to assume that the concentration of the drainage water is the same as that of the saturation extract (EC_e) at the bottom of the rootzone. An appropriate value can be chosen from table 2.4 and then the calculation made.

For example, if Creeping bentgrass (*Agrostis stolonifera*) has an EC_e of 3 - 6 dS/m and the irrigation water is 2 dS/m (say, 1400 mg/L) the leaching requirement is 33 - 66%. That is, the amount of irrigation required is 33 - 66% greater than if low salinity water is used.

The DNRQ (1997) has produced a water facts sheet (DNRQ97089) on salinity that includes the salt tolerance of a wide range of ornamentals that are useful for non-turf and landscaped areas.

- To avoid short-term high salt concentrations, do not allow excessive drying out of the soil.
- Maintain adequate soil permeability through subsoil aeration and thatch control.
- Irrigate at night to avoid salt burn.
- Irrigate with freshwater whenever possible to aid leaching.
- Conduct soil analysis to monitor soil soluble salt and cation levels. Adjust as required, e.g. apply gypsum to counteract Na accumulation.
- Maintain adequate nutrient levels including K, Ca, Mg and P.
- Construct on sandy soils whenever possible.
- Install subsoil drainage into low-lying and poorly drained areas that are likely to accumulate salts.

Table 2.9: Estimated salt tolerance of common turfgrasses (Harivandi et al. 1992)

Cool-season turfgrass		**Warm-season turfgrass**	
Name	**Rating***	**Name**	**Rating***
Alkaligrass (*Puccinellia* spp.)	T	Bahiagrass (*Paspalum notatum* Fluegge)	MS
Annual bluegrass (*Poa annua* L.)	S	Burmudagrass (*Cynodon* spp.)	T
Annual ryegrass (*Lolium multiflorum* Lam.)	MS	Blue grama (*Boutleoua gracilia* (H.B.K) Lag. ex. steud.)	MT
Chewings fescue (*Festuca rubra* L. spp. *commutata* Gaud.)	MS	Buffalograss (*Buchlon dactyloides)* (Nutt.) Engelms.]	MT
Colonial bentgrass (*Agrostis tenuis* Sibth)	S	Centipedegrass (Eremochla ophiuroides) (Munro) Hackell]	S
Creeping bentgrass (*Agrostis palustris* Huds)	MS	Seashore paspalum (*Paspalum vaginatum* Swartz.)	T
Creeping bentgrass cv. Seaside	MT	St Augustinegrass [(*Stenotaphruum secundatam* (Walter) Kruntze]	T
Creeping red fescue (*Festuca rubra* L spp. *Rubra*)	MT	Zoysiagrass (*Zoysia* spp.)	MT
Fairway wheatgrass [*Agropyron cristatum* (L.) Gaertn.]	MS		
Hard fescue (*Festuca longifolia* Thuill.)	MT		
Kentucky bluegrass (*Poa pratensis* L.)	MS		
Perennial ryegrass (*Loloium perenne* L.)	S		
Rough bluegrass *(*Poa trivialis *L.)*	S		
Slender creeping red fescue cv. Dawson (*Festuca rubra* L. spp. *trichophylla*)	MT		
Tall Fescue (*Festuca arundinacea* Schreb.)	MT		
Western wheatgrass (*Agropyon smithii* Rydb.)	MT		

**The rating reflects the general difficulty in establishment and maintenance at various salinity levels. It in no way indicates that a grass will not tolerate higher levels with good growing conditions and optimum care. The ratings are based on soil salt levels (EC_e) of: Sensitive (S) = <3 dS/m, Moderately Sensitive (MS) = 3–6 dS/m, Moderately Tolerant (MT) = 6–10 dS/m, Tolerant (T) = >10 dS/m.*

2.6 IMPROVING IRRIGATION EFFICIENCY

Water is a valuable resource that is shared with the entire community and therefore must be managed responsibly and used efficiently. Irrigation is a considerable cost on all golf courses, whether it is the direct cost of the water supply or the cost of pumping it. Irrigation systems can be inefficient for several reasons.

Factors affecting irrigation efficiency include:

- poor sprinkler uniformity;
- leaks (e.g. from valves, pipework, sprinklers);
- inadequate operating pressure;
- malfunctioning valves;
- sunken sprinkler heads;
- incorrect nozzles;
- incorrect rotation of sprinkler heads; and
- inadequate control system

These all contribute to the ineffective application of water and uneven watering. As a result, the system will be operated to pick up dry areas, which in turn will result in the overwatering of other areas. This not only wastes water, it also results in a turf of uneven health and quality as a playing surface.

The performance and management of the irrigation system must be evaluated on a regular basis (Connellan 2000). This includes both the performance of the irrigation system (i.e. the mechanics of the system and how uniformly water is applied) and how well the system was managed over the irrigation season (i.e. the amount of water applied compared to the amount that should have been used).

2.6.1 Irrigation management indicator

The quantitative measure of how much water is applied versus the demand can be used both as a post-mortem of the water use for the previous season and as a prediction of the expected water use for the season ahead. The irrigation index is a seasonal performance indicator that can be used to compare the amount of water actually used versus the estimated quantity required (Connellan 2000). It is expressed as follows:

$$\text{Irrigation Index (I)} = \frac{\text{Water applied to site}}{\text{Estimated water required}}$$

The amount of water applied can be easily determined from total water consumption at the site and the size of the area being irrigated. To assist in this process, regular meter readings should be taken. Modern pumping and control equipment will also provide this information.

The estimation of water required or plant water use is the estimation of the amount of water that should have been used by the site over a particular period or season and is somewhat more involved; however, the basic information is readily available.

Plant water use or evapotranspiration (ET) can be calculated using local climatic data and, in particular, evaporation from an A-pan evaporimeter.

$$\text{Plant water use (ET) in mm} = \text{Epan} \times \text{Crop Factor (CF)}$$

The value of CF will vary depending on the turf type, available soil water, management practices and, most importantly, the quality of turf required. In the following examples, crop factors of 50%, 60% and 70% have been used for couchgrass (Cynodon spp.). A higher CF is used for putting greens than for fairways, where the CF could be as low as 30%.

Rainfall needs to be factored into the water requirement equation and, most importantly, the amount of rainfall actually used or available to the plant, i.e. the effective rainfall. The effective rainfall is that proportion of the rainfall that is used by the plants after all the rainfall losses have been taken into account. The main factors to consider are:

- Rainfall in excess of soil storage capacity is lost through drainage beyond the rootzone.
- Rainfall intensities greater than the infiltration rate of the soil will result in some runoff.
- Very small amounts of rainfall will add very little water to the rootzone due to losses by evaporation from the turf surface. Rainfall of less than 2 mm can be ignored.

The irrigation requirement to satisfy plant requirements can then be expressed by:

$$\text{Net Irrigation Requirement (IR) in mm} = \text{ET} - \text{Effective Rainfall}$$

Due to inefficiencies, the sprinkler system needs to apply more water than the estimated irrigation requirement (IR). Some water is lost due to wind drift and evaporation, some may drain below the rootzone and there is always unevenness in application. The system efficiency, which accounts for the losses, can range from 50% to 90%, with a minimum acceptable efficiency of 80%. The water required can then be calculated as follows:

$$\text{Water required in mm} = \frac{\text{Net Irrigation Requirement (IR)}}{\text{System Efficiency (use 75\% as a minimum)}}$$

The Bureau of Meteorology has an excellent website (www.bom.gov.au) where climatic averages are available for various locations. This information can provide a very good preseason predictive model. Appendix 1 provides example tables of rainfall and evaporation for various New South Wales locations.

As an end-of-season assessment of irrigation efficiency or on a month-by-month assessment, the irrigation index should be calculated and ideally will be about 1.0.

2.6.2 Sprinkler uniformity performance

It is not possible to achieve efficient irrigation if the water is not applied uniformly. The ‘catch can’ test is used to determine sprinkler uniformity. Cans are placed at regular sprinkler intervals within the sprinkler pattern and the system is then run for sufficient time to ensure that a measurable amount of water is collected (figure 2.1). The preferred measure of uniformity for turf is DU (Connellan 1997).

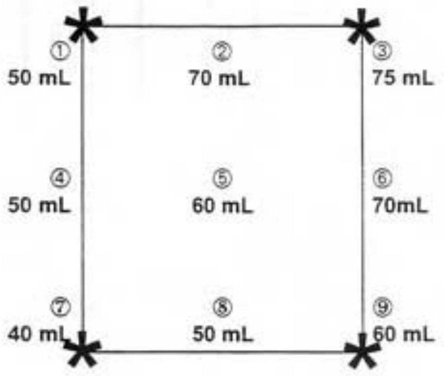
The DU places emphasis on areas of turf that receive low amounts of water and is calculated by comparing the average of the lowest 25% of can readings to the overall average. The equation is as follows:

$$\text{DU (\%)} = \frac{\text{Lowest 25\% of readings}}{\text{Average of all readings}} \times 100$$

A DU greater than 85% is considered acceptable for turf sprinkler systems. The can test not only provides information on system uniformity, it also gives a precipitation rate in millimetres/hour. Too often, irrigation is scheduled on run times in minutes, rather than the amount of water applied.

Figure 2.2: ‘Catch can’ test layout IRRIGATION CHECKLIST

AN EXAMPLE: Calculation of Distribution Efficiency for an Irrigation Zone



① Catch Can
* Sprinkler Head
50 mL - Volume of Water Collected in Catch Can

Number of Catch Cans	=	9
25% of Catch Cans	=	9 x .25
	=	2.25 (say 2)
Average Water Collection in Lowest 25% of Catch Cans	=	(40+50)/2
	=	45 mL
Overall Average Water Collection	=	(40+50+50+50+60+60+70+70+75)/9
	=	58.3 mL

$$\text{D.U.} = \frac{45}{58.3} = 0.77$$

Since D.U. is less than 0.85, it is concluded that the system isn't operating efficiently.

IRRIGATION CHECKLIST

Irrigation is a relatively complex task, with numerous factors affecting the efficiency of water use. The following is an example of a checklist that could be developed to provide a quick guide to some of the tasks that need consideration.

Task	Result	Date
1. Check water quality for key constituents:		
pH		
electrical conductivity (EC)		
sodium		
calcium		
magnesium		
sodium adsorption ratio		
carbonate		
bicarbonate		
chloride		
2. Undertake irrigation audit	**YES / NO**	
3. Update water, salt and nutrient balances based on monitoring data		
4. Calculate irrigation efficiency	**Ii =**	
5. Check sprinkler distribution on representative:		
greens	**DU =**	
tees	**DU =**	
fairways	**DU =**	
6. Collect monthly weather data:		
evaporation		
rainfall		
maximum temperature		
humidity		
7. Check controller operation—pre-season		
8. Check pump operation—pre-season		
9. Record monthly water consumption		

2.6.3 Irrigation control

An efficient irrigation system is one that has been competently designed, incorporates quality hardware, is installed correctly and is managed according to plant water needs and soil conditions. The crucial link between the irrigation hardware and the achievement of efficient water use is effective control (Connellan 1995).

The requirements of an automatic irrigation controller have been described by Peasley (1992) and are summarised below.

i. Basic requirements

- To operate reliably when required and to complete the planned schedule completely without fault.
- To apply the correct depth of water to the irrigation area during every scheduled irrigation and throughout every irrigation season.
- To apply the correct depth of water at the correct rate to suit the soil infiltration rate and the crop requirement.
- To be easy to operate.

ii. More sophisticated requirements

- To apply the correct depth of water to the irrigation area as efficiently as possible by optimising:
  - the plant/moisture synergy that causes healthy growth;
  - the design of practical watering schedules;
  - uniformity of application;
  - water consumption;
  - construction costs;
  - energy costs;
  - labour costs; and
  - maintenance costs.

- To provide specialised functions for specific management tasks such as:
  - scheduling based on moisture monitoring;
  - scheduling based on weather station monitoring;
  - multiple repeat cycle or pulse irrigation;
  - historical record keeping and statistical analyses;
  - pump control;
  - filter flushing;
  - volume metering;
  - heat stress suppression;
  - runoff control;
  - groundwater monitoring;
  - soil electrical conductivity (salinity) monitoring;
  - frost control by temperature monitoring;
  - fertigation metering; and
  - burst pipe isolation.

On golf courses, the irrigation control system is typically a Master/Satellite local network control system that features a central computer, controlling a multitude of satellites by various methods of communication — two-wire cable, radio, microwave etc. These systems can be interfaced with soil moisture sensors, weather stations, pumping plants etc.

In terms of the controller satisfying the requirements of the golf course it must have the following characteristics (in order of importance):

- reliability
- durability
- ease of programming

- sensor inputs
- flexibility
- program performance
- monitoring
- recording capability
- alarm facility
- remote communication.

Quality irrigation systems that aim to achieve efficient water use should incorporate some form of feedback into the control process (Connellan 1995). Two basic approaches can be taken: (i) use of soil moisture sensors, and (ii) use of predictive plant water use models.

2.6.4 Soil moisture sensors

Turfgrasses obtain their water needs from the soil and it makes sense to monitor the changing soil moisture status as a method of irrigation scheduling. Soil moisture sensors that are accurate and reliable can provide real-time information on the soil moisture status. They are particularly useful in providing feedback on the effectiveness of an irrigation or rainfall event and at what point the dry-down cycle is as a means of determining when the next irrigation is likely to be necessary. Soil moisture sensors also have the capacity to provide additional information such as soil nutrient status (by EC) and soil temperature. Trials carried out by Krieg (1994) demonstrated that using soil moisture sensors could reduce water use by up to 50% compared to irrigating by observation/experience.

Different types of soil moisture monitoring devices use different methods of determining soil moisture content. These include gypsum or porous ceramic blocks and tensiometers, neutron probes, capacitance probes and heat pulse soil moisture sensors.

Independent trials undertaken by the Australian Irrigation Technology Centre (AITC) tested the performance of twelve different environmental devices at various sites around Australia (AITC 1996). They included rain switches, evaporimeters and soil moisture sensors. The trial demonstrated a wide range of performance and the importance of the correct installation of this equipment. Two products, a small plastic evaporimeter ('Aquamiser') and a differential dehydration tension type soil sensor ('Watermatic'), demonstrated good performance.

In Western Australia, nine types of sensors were evaluated for use on irrigated horticultural crops on sandy soils (Luke et al. 1994). Of the sensors evaluated, the 'Watermatic', 'Hydroprobe', 'Enviroscan' and 'Loktronic' performed reliably, in accordance with the manufacturers' instructions. Moller et al. (1996) demonstrated the effectiveness of using the 'Enviroscan' for scheduling irrigation with up to a 60% reduction in the requirement for irrigation on warm season grass sportsfields. In the trials undertaken, they also detailed the potential cost-effectiveness of adopting a managed irrigation regime (table 2.10)

Table 2.10: Return on investment for 100 and 500 hectares of turfgrass, amortized over 5 years (Moller et al. 1996)

Area (ha)	Management units	Capital cost ($)	Capital cost ($/annum)	Saving ($/annum)	Return on investment (%)
100	3	60,000	12,000	49,000	408
500	15	300,000	60,000	245,000	408

The use of 'Watermatic' sensors has also demonstrated considerable savings in fertiliser by minimising leaching losses on sandy soils. Neylan and Robinson (1995) reported that with irrigation control by observation an application of soluble fertiliser was leached out of the rootzone within 5 days of application, whereas under sensor control the fertiliser lasted up to 25 days.

The key requirements for soil moisture sensors (Connellan 1995) are that they:

- operate effectively in a wide range of soil types;
- respond accurately and rapidly to changing soil moisture conditions;
- have simple calibration;
- operate in confined rootzones;
- are easily installed and provide a good soil/sensor interface;
- have output signals that are compatible with irrigation controllers and/or computers;
- are electrically and electronically sound and reliable;
- have long-term wetting and drying reliability;
- are of robust construction; and
- have minimum ongoing maintenance requirements.

The efficiency of irrigation management on golf courses in New South Wales is unknown, though many golf courses have the equipment to provide a high level of water use efficiency.

2.6.5 Control prediction models using weather stations

The use of predictive models to calculate plant water use has been described in section 2.6.1; however, with the introduction of on-site weather stations, localised predictive models can be used to schedule irrigation. The main advantage of the on-site weather station is the climate data will be more site-specific than Bureau of Meteorology data, which is likely to be from a more remote location.

The accuracy of this technique is dependent on the quality of the mathematical expression used to calculate the evapotranspiration rate (ET) and the quality of the climatic data used in the calculations. Generally, the accuracy will increase with the number of parameters measured, the frequency of the readings and the accuracy of the readings.

2.6.6 Pumping

The most significant advance in irrigation pumping technology for golf courses has been the introduction of the variable frequency drive (VFD) (Brockway 1997). In the USA, VFD systems represent 80% of the pump stations sold to golf courses. VFD stations vary pump speed to meet flow demands, whereas with the fixed speed system the pump operates at a fixed speed and a pressure-reducing valve constantly opens and closes to maintain a constant irrigation pressure as the flow changes. It is common for fixed speed booster pumps to operate at 20–50 PSI more pressure than is required.

The VFD station uses a pressure transducer to relay pressure information back to the VFD. As the flow demand increases, output pressure decreases. The VFD senses this and increases motor speed to increase pressure. Brockway (1997) provides a cost analysis of the VFD system, described below:

- **Initial cost:** VFD booster systems typically cost 20–35% more than a comparable fixed speed system.
- **Operating cost:** VFD systems generally reduce electricity costs by 20–50%.
- **Maintenance costs:** Over the life of the pump system, the maintenance cost of a VFD station should be less than that of a fixed speed station. However, a poorly maintained system can be very expensive to repair.
- **Smoothness of operation:** A VFD system will be much softer on the piping system. The gradual 'ramping up' to speed and continual speed modulation minimise water hammer and pressure surges.
- **Complexity:** Basic VFD controls are simpler than those of fixed speed stations. VFD stations are simpler to calibrate, although the electronics can be quite sophisticated.
- **Susceptibility to lightning and power surges:** High-quality surge protection devices have been developed that protect VFDs in the golf industry.
- **Headache factor:** VFD systems overall absorb less maintenance and repair time than a comparable fixed speed system.

Overall, the operational goal of a pump station manufacturer is to 'build a pump station that reliably and efficiently sequences pumps to provide variable flow rates at a constant discharge pressure. Pumping systems should eliminate air and offer sufficient alarms and shutdowns to protect the integrity of both the pump station and irrigation system'.

CASE STUDY: Pump replacement benefits

In the eco-efficiency survey at Horton Park Golf Course it was recommended that a review and upgrade of the pumping system be undertaken. It was proposed to install four 5 kw pumps to replace the existing 21 kw pump so there was greater flexibility in operation, depending on the water demand. For this particular site it was estimated that there would be a power saving of 29 200 kwh.

• Cost of multistage pump	$22,000
• Cost of a standard pump	$12,000
• Power saving (29 200 kw/h @ 7.348 c/kwh)	$2,145
• Payback period	4.6 years

Other than the power savings, there is less wear and tear on the pumps, irrigation pipework and sprinklers.

2.6.7 Water audits

An irrigation audit is a critical first step in improving irrigation efficiency. The irrigation audit determines the overall condition and effectiveness of the irrigation equipment and its operation.

Some of the problems that may be identified in undertaking an audit include:

- poor sprinkler uniformity;
- leaks (e.g. valves, pipework, sprinklers);
- inadequate operating pressure;
- malfunctioning valves;
- sunken sprinkler heads;
- incorrect nozzles;
- incorrect rotation of sprinkler heads,
- inadequate control system;
- broken casings and missing parts;
- distorted spray distribution;
- broken seals; and
- tilted irrigation heads.

The Irrigation Association of Australia (IAA) offer a Water Audit training course designed for hands-on operators that provides them with the skills to evaluate turf irrigation systems.

IRRIGATION ASSOCIATION OF AUSTRALIA (IIA) – WATER AUDIT TRAINING COURSE OBJECTIVES

- Turf water requirements and irrigation needs
- Development of appropriate irrigation control and scheduling programs
- Understanding the performance of irrigation systems
- Inspecting and assessing irrigation system hardware
- Irrigation performance evaluation. Testing an irrigation system
- Analysing irrigation system test results
- Developing strategies and formulating recommendations to improve the performance of irrigation systems.

Undertaking an irrigation system audit and documenting the findings benchmarks the current condition of the system and allows decisions to be made on what needs to be done to improve the operational efficiency. This then allows appropriate budget allocations to be made.

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LONG TERM MONTHLY EVAPORATION AND RAINFALL DATA
SYDNEY AIRPORT AMO Latitude: 33.94 S Longitude: 151.17 E

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EVAPORATION (mm)	220	182	164	123	87	78	84	115	141	177	195	229	1794
RAINFALL (mm)	100	111	122	106	98	123	69	81	62	73	82	75	1102
E-R (mm)	120	71	43	17	-11	-46	14	34	79	104	113	155	692.1
ET-50%(mm)	60	36	21	8	-6	-23	7	17	39	52	57	77	346.1
ET-60%(mm)	72	43	26	10	-7	-27	9	20	47	62	68	93	415
ET-70%(mm)	84	50	30	12	-8	-32	10	24	55	73	79	108	484
ET-80%(mm)	96	57	34	13	-9	-36	12	27	63	83	90	124	554

LONG TERM MONTHLY EVAPORATION AND RAINFALL DATA
CANBERRA AIRPORT Latitude: 35.30 S Longitude: 149.20 E

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EVAPORATION (mm)	251	202	171	108	66	50	53	78	111	158	192	251	1689
RAINFALL (mm)	62	54	53	50	49	40	42	47	53	66	65	53	631
E-R (mm)	190	148	118	59	17	10	11	30	58	93	128	198	1059
ET-50%(mm)	95	74	59	29	9	5	5	15	29	46	64	99	529
ET-60%(mm)	114	89	71	35	10	6	6	18	35	56	77	119	635
ET-70%(mm)	133	104	83	41	12	7	7	21	41	65	89	139	741
ET-80%(mm)	152	118	94	47	14	8	9	24	47	74	102	158	847

LONG TERM MONTHLY EVAPORATION AND RAINFALL DATA
COFFS HARBOUR MO   Latitude: 30.31 S   Longitude: 153.11 E

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EVAPORATION (mm)	202	165	161	126	90	81	84	112	144	174	189	202	1728
RAINFALL (mm)	185	211	248	183	171	118	77	79	63	90	133	151	1708
E-R (mm)	17	-46	-87	-57	-81	-38	6	33	81	84	57	51	20
ET-50%(mm)	9	-23	-43	-29	-41	-19	3	16	41	42	28	25	10
ET-60%(mm)	10	-27	-52	-34	-49	-23	4	20	49	50	34	30	12
ET-70%(mm)	12	-32	-61	-40	-57	-26	4	23	57	59	40	36	14
ET-80%(mm)	14	-37	-69	-46	-65	-30	5	26	65	67	45	41	16

LONG TERM MONTHLY EVAPORATION AND RAINFALL DATA
ORANGE AGRICULTURAL INSTITUTE   Latitude: 33.32 S   Longitude: 149.08 E

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EVAPORATION (mm)	217	179	155	96	60	40	47	65	90	130	162	217	1458
RAINFALL (mm)	93	70	58	55	77	69	94	103	83	93	75	79	949
E-R (mm)	124	109	97	41	-17	-29	-47	-38	7	37	87	138	510
ET-50%(mm)	62	55	49	20	-8	-15	-24	-19	4	19	44	69	255
ET-60%(mm)	75	65	58	24	-10	-17	-28	-23	4	22	52	83	306
ET-70%(mm)	87	76	68	28	-12	-20	-33	-26	5	26	61	97	357
ET-80%(mm)	99	87	78	33	-13	-23	-38	-30	6	30	70	110	408

LONG TERM MONTHLY EVAPORATION AND RAINFALL DATA
WAGGA WAGGA AGRICULTURAL INSTITUTE Latitude: 35.05 S Longitude: 147.34 E

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EVAPORATION (mm)	304	246	211	120	60	43	40	62	93	146	207	304	1836
RAINFALL (mm)	40	42	41	43	44	50	46	51	45	55	42	42	540
E-R (mm)	264	204	170	77	16	-6	-6	11	48	91	165	262	1297
ET-50%(mm)	132	102	85	39	8	-3	-3	6	24	45	82	131	648
ET-60%(mm)	159	123	102	46	10	-4	-3	7	29	54	99	157	778
ET-70%(mm)	185	143	119	54	11	-4	-4	8	34	63	115	184	908
ET-80%(mm)	211	163	136	62	13	-5	-5	9	38	72	132	210	1037

LONG TERM MONTHLY EVAPORATION AND RAINFALL DATA
WELLINGTON RESEARCH CENTRE Latitude: 32.50 S Longitude: 148.97 E

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EVAPORATION (mm)	267	216	192	126	75	53	53	74	102	155	204	267	1783
RAINFALL (mm)	66	59	52	44	49	40	47	49	45	64	57	51	625
E-R (mm)	200	157	140	82	26	13	6	25	57	91	147	216	1158
ET-50%(mm)	100	78	70	41	13	6	3	13	28	45	73	108	579
ET-60%(mm)	120	94	84	49	15	8	3	15	34	54	88	130	695
ET-70%(mm)	140	110	98	57	18	9	4	18	40	63	103	151	810
ET-80%(mm)	160	125	112	65	21	10	4	20	45	72	117	173	926

LONG TERM MONTHLY EVAPORATION AND RAINFALL DATA
WILLIAMTOWN RAAF Latitude: 32.79 S Longitude: 151.83 E

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EVAPORATION (mm)	211	174	149	114	78	78	81	109	138	171	189	226	1716
RAINFALL (mm)	104	118	123	101	110	123	73	80	59	76	80	81	1127
E-R (mm)	107	56	26	13	-32	-45	8	29	79	94	109	145	589
ET-50%(mm)	53	28	13	7	-16	-23	4	14	40	47	55	73	295
ET-60%(mm)	64	34	15	8	-19	-27	5	17	48	57	66	87	353
ET-70%(mm)	75	39	18	9	-22	-32	5	20	56	66	76	102	412
ET-80%(mm)	85	45	20	11	-25	-36	6	23	63	75	87	116	471

Period in which evapotranspiration exceeds rainfall and irrigation is likely to be required.

SECTION THREE
Integrated Pest Management

Contents

SECTION 3: Integrated Pest Management

KEY CONCEPTS

- Integrated pest management (IPM) is a tool that needs to be developed for each golf course.
- It is a multidisciplinary, ecologically based pest management system.
- It will minimise the use of pesticides, thereby reducing the risk of chemical run-off and water pollution
- It utilises **all** the available methods to keep pests at acceptable levels and requires:
  - *understanding course conditions and characteristics;*
  - *surveying pest species and knowing their life cycles;*
  - *defining pest damage thresholds;*
  - *developing a monitoring and record keeping program; and*
  - *developing and implementing pest control strategies.*
- IPM strategies dictate using the most safe, effective, economical and environmentally friendly measures available.

3.1 INTRODUCTION

An integrated pest management (IPM) program is a multidisciplinary, ecologically based pest management system that uses all available methods to keep pests at acceptable levels while minimising the effects on people, environment and turf. Pesticides remain a part of an IPM program, but they are only one of several options available to managers for controlling pests. Other options include genetic, regulatory, physical, biological and cultural solutions.

An effective IPM program is based on tolerating a level of pest damage that does not significantly reduce the acceptability of the turf. For a golf course, acceptable levels can be defined as the number of pests beyond which the aesthetics of the course and the playability of the turfgrass are compromised.

The components of an IPM program can be defined under the following headings:

- understanding course conditions and characteristics;
- surveying pests on the course;
- defining pest damage thresholds;
- developing a monitoring and record-keeping program; and
- developing and implementing pest control strategies.

3.2 COURSE CONDITIONS

This component of an IPM program involves collecting information on existing course conditions that could affect the ability of the turfgrasses to withstand pest infestations. Specific information to be collected includes:

- grass types;
- amount of shade;
- tree effect on air movement;
- soil type;
- soil fertility;
- site drainage;
- current cultural practices (e.g. mowing, fertilisation, irrigation etc.); and
- other site factors that may influence turf vigour and pest infestation.

These factors should be described for each hole of the golf course and the following checklists (Tables 3.1 and 3.2) can be used to note the relevant information.

Table 3.1 Checklist: Golf course conditions — Fairways

Hole no.	Predominant soil type	Topography	Drainage features	Grass type(s)	Shade effects	Other comments

Examples of conditions:

Topography: flat, slightly undulating, steep
Drainage features: poorly drained, some low areas, good drainage
Shade effects: no shade, moderate, winter only

Table 3.2 Checklist: Golf course conditions — Greens/Tees

Hole no.	Predominant soil type	Thatch depth	Grass type	Shade and air movement	Root depth	Surface features	Drainage characteristics	Other comments

Examples of conditions:

Shade effects:	no shade, moderate, heavy
Air movement:	good air movement, poor, protected from north, south, east or west
Surface features:	flat, undulating, limited pin placements
Drainage characteristics:	good, moderate, poor

3.3 MONITORING PROGRAMS

The development of a reliable monitoring program is the key to a successful IPM program. Overseas research indicates that where successful monitoring programs are implemented, chemical reductions in the order of 40–50% can be achieved. (NZTCI 1995).

Monitoring is an ongoing process and provides:

- early detection of a developing problem;
- location of the problem pests; and
- pest population status, which can be evaluated at various times of the year.

Monitoring a turf area for pests involves inspecting the area regularly (at least weekly and daily during key periods when pests are likely to occur) and recording any insect, weed or disease. Accurate and detailed records are required and include:

- identification;
- location;
- number present; and
- stage of life cycle (insects).

Table 3.3 shows an example of a pest monitoring sheet.

Table 3.3 IPM monitoring report

Turf area (green, tee or fairway): ____________________ **Date:** ______________

Person undertaking observations: ____________________ **Time of day:** ______________

Hole no.	Location	Disease	Weeds	Insects	Comments

Examples of conditions:

Location: rear of green, poorly drained area of fairway
Disease: name if known, or describe symptoms
Weeds: name, size, extent
Insects: name or general description, larvae or adults
Comments: severity of pest present (e.g. number of spots, number of grubs, size of area affected), sample sent for identification.

In addition to the monitoring information, it is also important to record the climatic conditions, which are easily obtained from the Bureau of Meteorology (www.bom.gov.au).

Climatic data to be recorded include:

- maximum and minimum temperatures;
- rainfall;
- humidity;
- sunshine hours or cloud cover; and
- wind.

Regular monitoring enables threshold damage levels to be determined. Once damage thresholds have been exceeded, control strategies can be implemented. If chemical treatment is necessary, treatments should be restricted to the target area rather than blanket spraying, which will substantially reduce the amount of chemical used.

3.3.1 Insect monitoring

- Irritating solutions can be used to flush surface-feeding insects to the surface. Dishwashing liquid (lemon-scented) at about 20 ml in 5 L of water and pyrethrum sprays (about 6 ml in 1 L of water) are effective flushing agents.
- Light traps and pheromone traps can be used to detect the presence of insects on the move (they do not provide accurate measure of numbers).
- Presence of underground grubs (e.g. scarabs) needs to be checked by peeling back the turf and examining the soil.
- Accurate identification is critical if cost-effective control is to be achieved.

3.3.2 Disease monitoring

- Most diseases require certain climatic conditions to develop (e.g. high night-time temperatures, high humidity).
- Indicator sites to be monitored daily. All golf courses have specific areas that are always affected first.
- Identify affected plant species/variety.
- Examine affected plants and identify any visible symptoms (e.g. lesions on leaves, lack of healthy roots etc.).
- Do not trust the pictures in the textbooks — have a positive identification made.

3.3.3 Weed monitoring

- Identify weed and size
- General site conditions
- Soils
- Drainage
- Compaction
- Shade

With regular monitoring, patterns will develop and can be useful to predict what is likely to happen in future years. When a pest is identified the following information should be recorded (Table 3.4).

Table 3.4 Pest monitoring sheet

Date of occurrence	Name of pests	Number of pests	Where encountered	Weather conditions	Method of control

3.4 DETERMINING PEST THRESHOLD DAMAGE LEVELS

Pest threshold damage levels describe the degree of pest infestation that can be tolerated in relation to course aesthetics and playability. Threshold levels can be very general (e.g. spraying for broadleaf weeds when they become visually noticeable), or quite specific (e.g. pesticide applications based on actual counts of insects).

It is essential that threshold levels be determined for each pest identified. They are going to be site-specific and developed in consultation with the course users and management. What is acceptable at one site may not be acceptable at another. Threshold levels should reflect the potential for serious turfgrass injury. For example, low threshold levels should be set for diseases that can cause extensive damage in a short period of time.

3.5 DEVELOPING AND IMPLEMENTING PEST CONTROL STRATEGIES

Pest control strategies can involve either cultural or non-cultural methods. Cultural methods are essentially preventative measures that reduce the extent of the pest problem and include:

- selecting appropriate turf cultivars;
- good fertility management;
- aerating compacted soils;
- improving drainage;
- thatch control;
- raising mowing heights;
- good irrigation management;
- minimising shade; and
- improving air movement.

Non-cultural techniques include:

- pesticides, and
- biological control agents.

The selection of a pesticide will take into account:

- selecting the lowest toxicity (yet effective) chemical;
- selecting a product that will be effective given soil and thatch conditions and grass type;
- the growth cycle of the pest;
- application method;
- duration of control required;
- rotation of pesticides of different modes of action; and
- possibility of environmental contamination.

Once a pest control strategy is implemented, check up on the result. Figures 3.1 and 3.2 provides an IPM decision flow chart that takes into account all factors connected with IPM programs.

Figure 3.1 Integrated Pest Management Decision Flow Chart (Peacock and Smart, 1995)

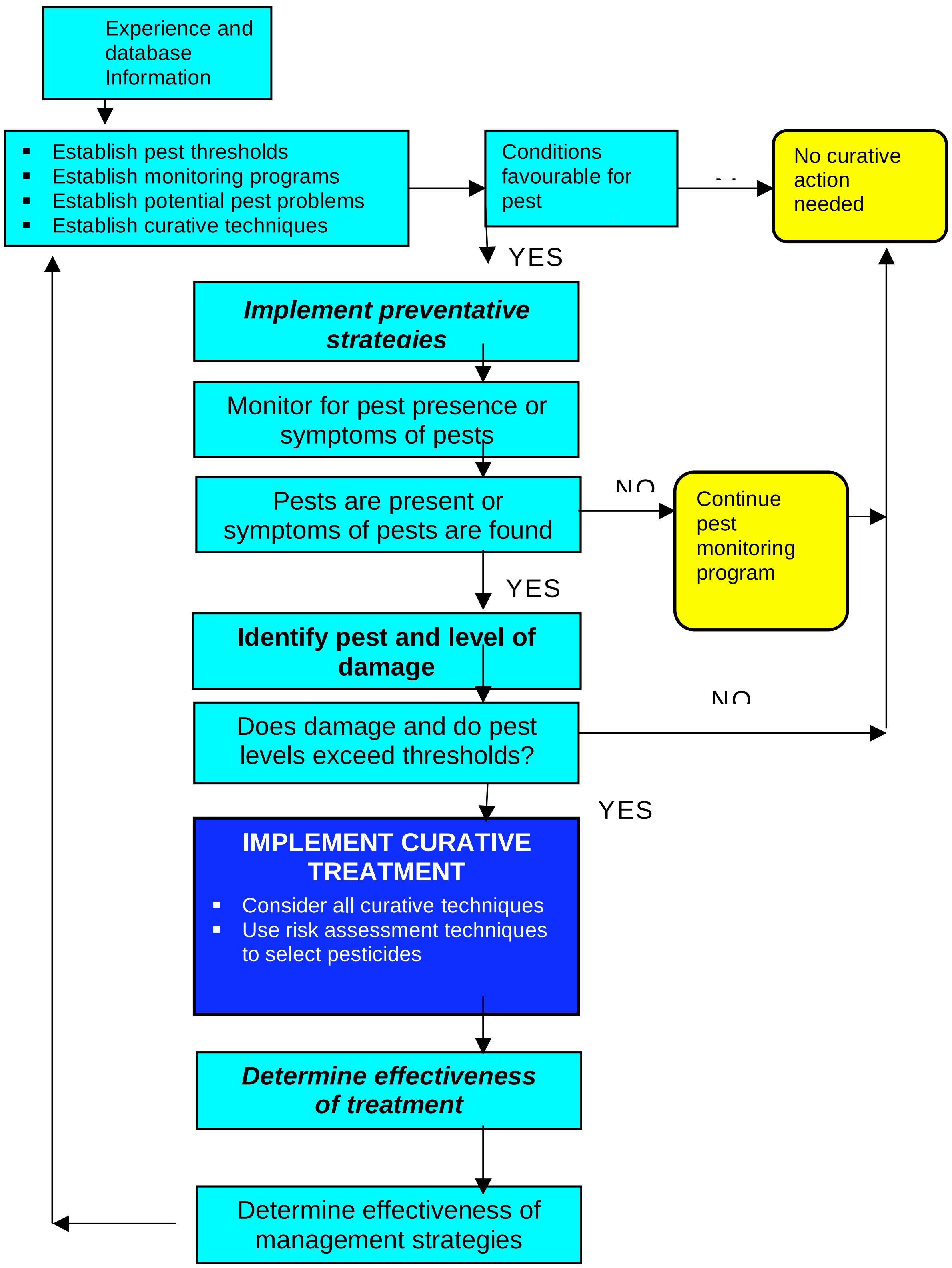
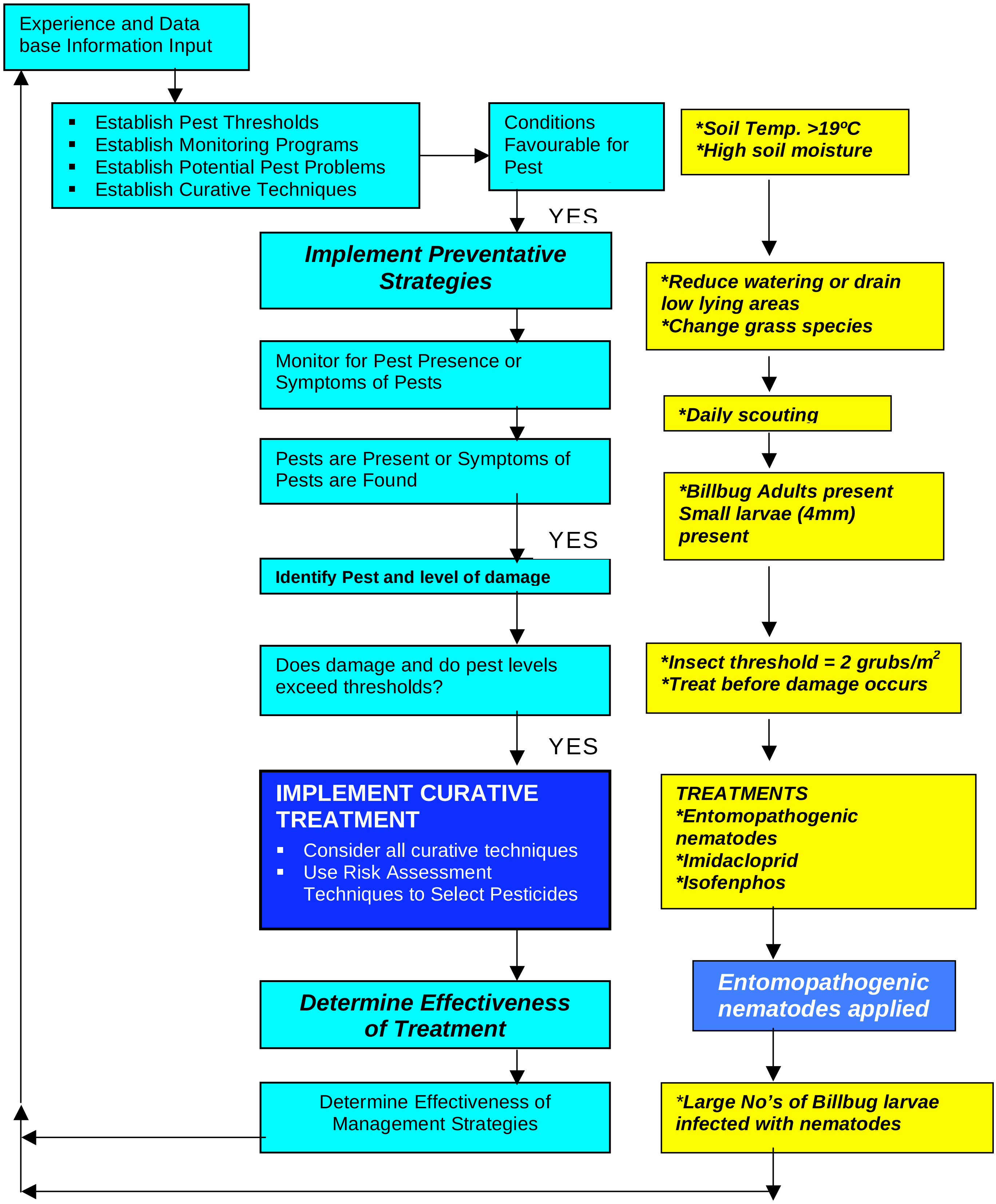


Figure 3.2 Integrated Pest Management Decision Flow Chart — Example (Peacock and Smart, 1995)



THE COSTS AND BENEFITS OF AN IPM PROGRAM

1. **IPM monitoring and recording**

   7.5hrs/week @ $25/hr **$9,759per annum**

   Regular monitoring formalises the process of gathering information about the golf course that assists in other management activities for example:

   - irrigation,
   - fertilising, and
   - drainage.

2. **An IPM program** allows pests to be controlled at the most vulnerable time of the life cycle. This will often result in a single pesticide application rather than multiple applications.

   For example: to control an insect pest using Dursban® (chlorpyrifos) will cost **$314/ha or $6,280 over 20 ha** (see section 4.1).

If we assume the IPM strategy provides 100% control then the potential benefits are:

- Not having to initiate a second or possibly third pesticide application (**saving $6,280 to $12,560**)
- Strategic spraying of 'hot' areas versus blanket spraying. Pest infestations often only cause a problem on 10–20% of the turf area. A risk assessment has to be undertaken based on the particular pest and the established damage thresholds.
- **Potential savings $5,024 to $5,652**

3. **Environmental/ ecological benefits**

   In the future it may be necessary to close down sections of the golf course each time a pesticide is applied. There are obvious benefits in minimising the number of pesticide applications and the consequent inconvenience to golfers and reduced revenue streams.

REFERENCES

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SECTION FOUR

Pesticide Storage, Handling and Application

Contents

SECTION 4: Pesticide Storage, Handling And Application

KEY CONCEPTS

- Pesticide use and safety remain major concerns for the public, golfers and golf course managers.

- The effective control of pests through the use of pesticides depends on:
  - accurate pest identification;
  - selecting the most effective and environmentally friendly pesticide;
  - minimising the use of pesticides, wherever possible
  - applying the pesticide accurately; and
  - calibration of the sprayer routinely checked as part of the spray task.

- Poor pesticide handling and application can:
  - waste money
  - waste time
  - provide poor pest control
  - result in turf damage
  - pollute ground and surface waters
  - harm wildlife
  - create occupational and public health and safety risks and
  - result in golfer and neighbour dissatisfaction.

4.1 INTRODUCTION

Pesticide use and safety and the environmental risks continue to be major concerns for the public, golfers and golf course managers. Modern pesticides are generally less persistent and more target-specific than earlier preparations, but all pesticides are biologically active and due care must still be taken in their storage, handling and application.

If pesticides are used poorly, they pose risks to workers, golfers, the community and the environment. The results of carelessness can range from the contamination of ground and surface waters to fish kills, death of non-target organisms and expensive clean-ups.

All reasonable precautions and due diligence needs to be applied to :

- pesticide storage;
- pesticide application practices;
- washdown bays;
- rinsate disposal; and
- pesticide waste and pesticide container waste management.

Under the *Protection of the Environment Operations Act 1997* (POEO) it is an offence to pollute waters (Section 120). It is also an offence to cause or permit water pollution.

'Waters' means the whole or any part of:

- any river, stream, lake, lagoon, swamp, wetlands, unconfined surface water, natural or artificial watercourse, dam or tidal waters (including the sea) or
- any water stored in artificial works, any water in water mains, water pipes or water channels, or any underground or artesian water.

Under POEO it is an offence to willfully or negligently cause a substance to leak, spill or otherwise escape in a manner that harms or is likely to harm the environment. Heavy penalties apply, including up to $1 million for a corporation and $250 000 and 7 years gaol for an individual.

4.2 THE PESTICIDES ACT 1999

Most NSW golf course superintendents and their staff are regular commercial users of pesticides and have particular responsibilities for the proper use of pesticides. Pesticides include herbicides, insecticides, fungicides, nematicides and baits for vermin. Under the *Pesticides Act 1999*, the NSW Department of Environment and Climate Change (DECC) enforces the proper use of all pesticides in NSW, after the point of sale. This includes pesticides used on public lands, in agriculture and on domestic and commercial premises. There have been significant changes in pesticides legislation in NSW with the introduction of the *Pesticides Act 1999* which replaces the older *Pesticides Act 1978*.

This Act is administered by the DECC. Under the *Pesticides Act 1999* all pesticide users must:

- use only registered pesticides
- read the pesticide label prior to each application
- use the pesticide in strict accordance with label directions (unless the user has a permit issued by the Australian Pesticides and Veterinary Medicines Authority to allow specific off-label use, in which case the requirements of the permit need to be followed strictly.)
- not cause harm to people, property or non-target plants and animals as a result of their pesticide application
- not store pesticides in containers which do not bear an approved label

Due diligence: Users of pesticides must read the labels of products they intend to use, assess each application thoroughly before using the pesticide and take all reasonable actions to ensure that non-target impacts are avoided. There is a defence to the offences of causing harm to people, property or non-target plants and animals where the user can demonstrate that she/he took all reasonable precautions to prevent the offence occurring and that it was due to causes over which they had no control.

Maximum penalties for most offences are $60,000 for individuals and $120,000 for corporations. Maximum penalties for offences committed wilfully or negligently are $120,000 and $250,000 respectively. Penalty Infringement Notices (like on-the-spot fines) can be issued for minor offences. Compliance notices can also be issued for cleanup.

Information specific to golf courses in relation to pesticide use and application: Several pesticides used on golf courses, including chlorpyrifos, bifenthrin, azinphos and fenamiphos have been found to cause major fish kills and/or the deaths of native birds when disposed of or used incorrectly (e.g. not watered in directly after application). For example, special care should be taken to ensure that wood ducks (which frequent golf courses) are not affected by pesticides even when used in accordance with the label. Areas where pesticides have been used may need to be netted or have physical barriers to prevent the wood ducks grazing on the treated greens. Timing of the pesticide use may also be important.

There are also anecdotal reports of illegal use of mercuric and arsenic products in the greenkeeping industry. These products are no longer registered as a result of their unacceptable environmental and health risks.

Possession or use of unregistered or cancelled products is an offence, and the DECC carefully investigates all incidents involving their possible use or possession with intent to use. Ensure that you follow all label directions, including those regarding the storage of pesticides and the appropriate disposal of rinsate or excess chemicals.

NSW DECC Pesticides Officers: Pesticide officers can advise you on your legal responsibilities and other pesticides issues. Pesticides officers can be contacted on the numbers given at the end of this section. From time to time, DECC Pesticides Officers may visit golf courses to investigate complaints about a pesticide incident or to audit aspects of pesticide use. Some of these visits may occur without prior warning. DECC Pesticides Officers have powers to enter and search premises, seize products, take samples and obtain information in the course of an investigation. DECC officers should show you their authorisation before commencing inquiries.

Investigations may lead to prosecution, as described in the DECC's Prosecution Guidelines (DECC 2001). For less serious offences, the DECC may issue a penalty notice (like on-the-spot fines). Penalty notice fines are much lower than prosecution penalties and do not lead to a criminal record. The DECC may also issue clean-up and prevention notices.

The DECC may also provide advice that the action was within the law, direct pesticide users to sources of advice on best practice use of pesticides, refer the incident to another authority where appropriate, or facilitate communication among people involved.

The DECC also undertakes audit programs to check compliance with aspects of pesticide use, such as compliance with new label directions set by the National Registration Authority for a particular product. For example, a compliance audit program may be implemented now that compulsory record keeping has come into force.

Record keeping regulation: Requirements for mandatory record keeping for all commercial pesticide users, including those using pesticides on golf courses were gazetted in December 2001. The record keeping requirements commenced at the end of July 2002. A substantial period was left from gazettal to commencement to give users time to learn about the new rules. Resources providing guidance on the record keeping requirements is available on the DECC website or by phoning Environment Line on 131 555. More details are provided in section 4.3.2

Proposed training regulation: The DECC has consulted on draft proposals for mandatory training of commercial pesticides users, including greenkeepers. It is proposed that commercial users will be required to undertake competency-based training/assessment before they can use pesticides. It is also proposed that people who have already undertaken training under the ChemCert (or former Farmcare) or SMARTtrain programs are deemed to meet the training requirements for 5 years after the date of issue of their qualifications. A phase-in period following commencement of the Regulation is also proposed to allow adequate time for users to be trained. The training proposal would give people the opportunity to have their current skills assessed and their competency certified under recognised prior learning programs rather than having to undertake formal training.

Notification: The Pesticides Implementation Committee has also been considering the use of notification in minimising the risk associated with pesticides use and in meeting community expectations of 'right-to-know'. It has recommended a multi-pronged approach that incorporates: the continued role of the Australian Pesticides and Veterinary Medicines Authority in identifying any product specific notification requirements during registration and assessment processes; the possible use of mandatory notification in certain sensitive situations such as near schools, hospitals, in common areas of multiple occupancy premises and in public places; and the development of voluntary notification principles (for pesticide use in agriculture). Consultation will occur as these issues progress.

Further information: Information sheets about the *Pesticides Act 1999* are available from the DECC's Environment Line on 131 555. These information sheets and other information about pesticides are also available on the DECC's website at www.environment.nsw.gov.au

Pesticides Officers in NSW can be contacted on the telephone numbers below :

Sydney	02 9995 5799	Dubbo	02 6884 9757
Newcastle	02 4908 6804	Tamworth	02 6766 7871
Grafton	02 6640 2511	Griffith	02 6964 1880
Queanbeyan	02 6122 3106		

4. 3 PESTICIDE APPLICATION PRACTICE

The application of plant protection chemicals is undertaken on most golf courses. Even on golf courses that have adopted an integrated pest management program, strategic spraying (in both time and location) is generally undertaken for the effective control of diseases, weeds and insects and is dependent on:

- careful monitoring of pest populations
- accurate identification of the pest
- selection of the most effective and environmentally friendly chemical
- accurate application of the pesticide

Spraying is a costly and time-consuming exercise. Being cost-effective depends on accurate application techniques. Every time the sprayer goes onto the golf course, there is always a natural suspicion of 'something nasty' being applied. Strategic spraying as part of an integrated pest management program, should reduce costs to the golf club and reduce the likelihood of causing concern to club users and neighbours.

4.3.1 Sprayer calibration

To spray a liquid is in itself a simple operation, but it is important that the sprayer be operated correctly and optimally for the conditions. Equipment factors to take into account include: nozzle size, spraying pressure, spray volume rate, forward speed and equipment maintenance (including calibration).

Other conditions to consider include: weather, turf characteristics, leaf angle, and growth stage.

Good spray technique entails careful consideration of:

- spraying equipment parameters (nozzle, pressure etc.);
- use of an effective calibration method;
- personal and public safety;
- environmentally sensitive areas, (e.g. near waterways)
- effective cleaning of the sprayer.

Regular sprayer maintenance is needed to provide sufficient and even distribution of the spray liquid and achieve effective pest control. The results from two overseas studies which checked the condition of spray equipment are summarised below.

STUDY 1: North Dakota, USA

- Only 18% of the sprayers checked were in excellent condition and applying the intended application rate.
- 60% of sprayers were more than 10% off the intended application rate (43% under-applying, 17% over-applying).
- 43% of sprayers had nozzle flow more than 10% off compared to new.
- 32% of sprayers had inaccurate travel speed variation from what was predicted.
- 27% of sprayers had improper boom height.
- 13% of sprayers had inaccurate pressure gauges.
- 8% of sprayers had inadequate hose size to supply nozzles.

Source: Hardi undated

STUDY 2: Danish Government Random Check of Spray Equipment (Law No. 266, 1993)

In 1995 of 454 sprayers checked, 341 (75%) failed the test:

- 34% due to damaged or worn nozzles;
- 23% had malfunction on suction filter; and
- 20% had malfunction of pressure gauge.

In 1997, of 408 sprayers checked, 319 (75%) failed the test:

- 57% due to damaged or worn nozzles;
- 52% had malfunction of pressure gauge; and
- 28% had leakages from fittings.

Source: Hardi undated

In addition to regular maintenance, sprayers need to be calibrated to ensure good performance. Poor calibration can lead to under or over application rates. Under application may result in poor treatment efficiency and over application can lead to higher costs for spraying and chemicals and increased risk of harm to the environment and occupational and public health. Poor results from pesticide application can lead ultimately to increased turf damage and golfer dissatisfaction.

Examples of the possible costs due to misapplication are given below:

SCENARIO 1: SPRAY APPLICATION IS 15% GREATER

Rate of application:

Chemical:	Dursban®
Application rate:	6 L/ha
Area:	20 ha
Volume of product applied:	120 L
Cost of product:	$170/5 L $4,080 ($204/ha)
Application time:	2.5 hours/ha (includes fill-up, application, travel)
Labour cost:	$50/ha
Equipment:	$60/ha
Cost per hectare:	$314
Total cost (20 ha):	$6,280

If the equipment is applying 15% more than expected, the increased cost is $942, and there may be additional labour costs in refilling spray equipment, greater fuel use and time.

SCENARIO 2: SPRAY APPLICATION IS 15% LESS

If the equipment is applying 15% less than expected, there are two possible outcomes:

- Spray is completely ineffective in controlling pest (cost: $5,338).
- Spray is partially effective in controlling pest and repeat spray is required at correct rate.
- In both situations, the potential costs will be $5,338 for the initial application plus $6,280 for the repeat application at the correct rate. Total cost: $11,618.

4.3.2 Record keeping

Good record keeping is an essential part of improving pesticide use efficiency and complying with the *Pesticides Act 1999*. The New South Wales Golf Course Superintendents Association has designed an excellent pesticide applicators log book for recording key information on the application of pesticides and calibration of equipment. Excerpts from the log book are provided below:

Date / /

Spray Licensee Name & contact details_______________________________________

Pesticide Applied (complete product name)
(Tick appropriate box then detail chemical used)

- ❑ Fungicide ____
- ❑ Insecticide ____
- ❑ Herbicide ____
- ❑ PGR ____
- ❑ Other ____

Rate: quantity of concentrate used; total volume of spray applied; areas of application____

Rate 2____

Spray Unit Calibration A B C Other (see over)

Spreader Setting______________________**Helicone Setting**____________________
Irrigation ______________________________**Rainfall**_______________
Other Additives____
Target Organism____

Area Treated (Tick appropriate box and/or specify area's sprayed)

❑ Greens	ALL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	PG	CG	NY
❑ Tees	ALL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	PG	CG	NY
❑ Fairways	ALL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	PG	CG	NY
❑ Other	ALL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	PG	CG	NY

Time Application Commenced_______________**Completed**_________________

Weather Conditions___________________________**Wind Speed**____________

Changes noted to wind strength and direction:

Additional Comments____

Diligent responsibility and care was enacted to ensure that the appropriate safety equipment was used during the course of chemical application and mixing.

Operators Name________________________Signature______________________

Spray Unit Calibration Settings

Equipment Information

A

Equipment Type:		Nozzle Type:	
Operating Speed:	Kph	Nozzle Size:	
Operating Pressure:	kPa	No. Nozzles:	
Swath Width:	m	Nozzle Output:	L/min
Boom Height:	cm	No. Droplets:	/cm²
Water Volume:	/ha or /plant	Calibration Date:	

Previous Sprayer/Boom use: ____________________

Method of Cleaning Sprayer: ____________________

Equipment Information

B

Equipment Type:		Nozzle Type:	
Operating Speed:	Kph	Nozzle Size:	
Operating Pressure:	kPa	No. Nozzles:	
Swath Width:	m	Nozzle Output:	L/min
Boom Height:	cm	No. Droplets:	/cm²
Water Volume:	/ha or /plant	Calibration Date:	

Previous Sprayer/Boom use: ____________________

Method of Cleaning Sprayer: ____________________

Equipment Information

C

Equipment Type:		Nozzle Type:	
Operating Speed:	Kph	Nozzle Size:	
Operating Pressure:	kPa	No. Nozzles:	
Swath Width:	m	Nozzle Output:	L/min
Boom Height:	cm	No. Droplets:	/cm²
Water Volume:	/ha or /plant	Calibration Date:	

Previous Sprayer/Boom use: ____________________

Method of Cleaning Sprayer:

4.4 STORAGE FACILITIES

In addition to general maintenance buildings, a facility dedicated to the storage of pesticides and fertilisers is required by Workcover NSW. This facility should be self-contained to minimise risk from spillage or fire. When constructing a chemical storage facility a Development Application should be submitted to the local council for approval.

If storing products that are classified under the *NSW Dangerous Goods Act 1975*, store in a manner which complies with the requirements of this Act. Depending upon the quantity stored, licensing by WorkCover NSW may be required.

When designing a storage facility, the following actions must be considered:

- Refer to information in material safety data sheets (MSDS).
- Check local council fire regulations for entry/exit positions in the building, wall and ceiling construction material and any other requirements.
- Locate the facility away from other maintenance buildings.
- Store fertilisers and pesticides separately (i.e. in separate rooms).
- Provide positive ventilation, containment area for spills, emergency shower, eyewash and first aid kit in pesticide storage room.
- Have no outgoing drains from the facility.
- Develop and practise emergency response plans.

4.5 PESTICIDE SPRAY TANK FILLING AND MACHINERY WASHDOWN BAYS

4.5.1 Spray tank filling facility

It is recommended that the filling and emptying of spray tanks, emptying of spray lines and equipment and triple or pressure rinsing of spray equipment take place on a separate facility to the machinery washdown bay. This will help prevent pesticide waste contaminating the larger volume of water, soil, vegetation and other waste that is generated by the washing of machinery on a golf course.

The chemical handling and spray tank filling area needs to be able to contain all spills that may occur and be isolated from the stormwater and sewer systems, streams, water bodies etc. Beard (2002) recommends that there be 37–84 square metres allocated for equipment cleaning. The minimum dimensions suggested are 6 x 6 metres with 9 x 9 metres preferred. However, the minimum area would need to adequately accommodate the largest machine.

There needs to be a containment area (e.g. concrete tank) that is capable of containing at least the volume of the entire largest application tank or pesticide container (whichever is the largest), plus some space for washdown, and provision for prior content. This containment area can be designed to service both the spray tank fill area and the chemical storage facility. The containment facility is designed to hold the spillage until a company that is accredited to handle, remove and dispose of chemicals can pump it out for appropriate hazardous waste disposal.

4.5.2 Machinery washdown facility

While many golf courses have a designated storage area for pesticides, only a few have dedicated washdown bays and even fewer treat the wastewater generated. The traditional washdown facility on many golf courses in Australia is at best a concrete washdown pad and pesticide mixing area, with a drain that discharges into a soakage pit, stormwater drain or directly to surface waters. Allowing contaminated wastewater from washdown bays to drain directly into stormwater or surface waters would be an offence and could lead to fines and/or notices being imposed on operators. Local councils regulate pollution of waters provisions applicable to golf courses under the *POEO Act*, unless that council is the golf course operator/owner (in which case the DECC becomes the regulator).

Washdown facilities also have to cope with clippings, oils and other contaminants. Of particular concern is the spillage of pesticide concentrates that could enter local waterways. Such an occurrence is not only environmentally unacceptable, but will also reinforce any community perceptions of golf courses being environmental polluters.

Washdown facilities are recommended to be separate from spray tank filling facilities to reduce the likelihood of a spill from mixing pesticides or filling or cleaning spray tanks and equipment lines. If such activities were conducted on the machinery washdown facility loading, it could lead to pesticide contamination of the greater volume of washdown water and render that waste water to be hazardous waste. Factors to consider when designing such a machinery washdown facility are listed below.

GENERAL CONSIDERATIONS FOR A MACHINERY WASHDOWN FACILITY

- The likely composition and volume of the wastewater.
- Characteristics of the local environment (e.g. natural surface and ground waters, endangered species and their habitats, remnant vegetation, adjacent land uses), that may be at risk from any releases or will receive any current or proposed stormwater or other discharges that have been appropriately treated.
- Legislative requirements including preventing water pollution (*POEO Act*).
- Installation and maintenance costs.
- Sufficient containment area/holding pit for washdown water.
- Collection and storage facility for washdown water for current or future use.
- Screen and settling pit fitted to trap solids such as soil and grass clippings.
- Interceptor pits to remove grease and oil.
- Facility to treat wastewater to reduce biological oxygen demand.
- Facility to reuse wastewater on site for irrigating turf areas (If appropriate and compliant with environmental and public health requirements).
- Water quality that meets requirements for approval of local sewage service provider for disposal of treated wastewater to sewer (if wastewater is to be disposed of in this manner).
- Regular cleaning and servicing of facility.
- Regular testing of wastewater and treated water to check treatment effectiveness.

Discharge to sewer as trade waste

In NSW, trade waste is controlled either under the legislation of the local water authority (e.g. Sydney Water) or, when a council is the water authority, under the *Local Government Act* and Regulations.

Council or the water authority sets the conditions under which trade waste may be discharged into the sewer:

- by setting charges for the collection, disposal and treatment; and
- by instituting trade waste permits, administration and inspection procedures

It is possible for wastewater to be discharged as trade waste to the sewer providing it meets the controlling authority's sewer admission limits. This often involves storing the wash water in a tank, to be discharged in a batch to the sewer once it has been tested by the sewerage authority.

Trade waste may be accepted into the sewerage system if it complies with council's or the water authority's requirements and only under the terms and conditions of a council trade waste permit/agreement. The permit controls the quality and quantity of trade waste, allowing it to be transported without having any adverse effects on the sewerage system, wastewater purification process, the safety of the workers or the environment. Wherever trade waste is generated, the property owner must apply to council or water authority on a prescribed form for a permit/agreement that allows the discharge of trade waste. A trade waste permit/agreement will have standard conditions as well as specific requirements for the particular demands of the activity. The agreement is negotiated on a case-by-case basis.

If a trade waste discharge is to be considered, it is important that the waste stream is analysed for the various contaminants that can be in the waste stream. Each council or water authority is responsible for setting its own limits and needs to be consulted locally for requirements.

During the compilation of this manual there were several site visits undertaken to inspect suitable washdown and storage facilities including Avondale GC, Camden Lakeside GC and Nelson Bay GC. The general set up of these washdown facilities was as follows:

- A concrete pad that slopes inwards towards a central pit. The design is such that all washdown water is contained and that no stormwater can enter the facility (the washdown pad is roofed to prevent rainwater entering).
- The water enters a pit in which there is a mesh screen to catch grass clippings. An appropriate lifting device (e.g. a gantry lift) is often needed to remove the grass screen as it can become very heavy.
- Water passes through the grass screen and then through a sand/silt trap to trap all soil particles.
- Water is then pumped through a triple interceptor pit to separate the oil/grease from the water.
- The clean water is then discharged to the sewer or other approved location. It may be possible to filter the water through a constructed wetland or to irrigate adjacent turf or garden areas.

- Most facilities minimize the amount of debris (grass, soil etc.) by dry blowing the machines before washing.
- The washdown facility is only used for washing machinery and not for pesticide mixing, filling or emptying spray tanks, or cleaning pesticide containers, spray tanks or spray equipment lines.

In terms of the size of the washdown facility, the minimum area would need to be adequate for taking the largest machine. At golf courses with larger numbers of machines it will be necessary to set up the facility so that multiple machines can be washed at the same time. This is important in ensuring that staff are not waiting unnecessarily until they can access the washdown facility. Beard (2002) recommends that there be 37–84 square metres allocated for equipment cleaning. (The minimum dimensions suggested are 6 x 6 metres with 9 x 9 metres preferred).

4.6 WASTE MANAGEMENT

4.6.1 Pesticide waste and pesticide container waste

It is best to not generate pesticide waste in the first place. This starts by ensuring that pesticides are only purchased that will be used within the year.

ChemClear is an industry-run and industry-funded scheme to collect and manage future agricultural chemical wastes. The scheme will provide for the collection and destruction of rural chemicals, (i.e. pesticides used on farms, forestry, or for pest or weed control on public, industrial and recreational land). Industry has advised that it will operate a pilot *ChemClear* chemical collection in NSW in 2003, and commence full-scale operation in 2004. More information can be obtained on *ChemClear* by contacting Agsafe, the chemical industry body that is managing the scheme, on: (02) 6230 4799.

In the absence of *ChemClear*, there are licensed hazardous waste contractors who will remove pesticide waste for disposal at a cost. The cost of such disposal is a strong incentive to manage the pesticide so that waste is not generated.

Pesticide containers should be triple or pressure rinsed after the container is emptied by being poured into the spray tank. This cleans the containers so that they are eligible for *drum*Muster, which is a national scheme for the collection and recycling of chemical containers. This program is funded by a levy of 4 cents per litre/kilogram of products sold in chemical containers over 1 litre/kilogram in content that are not otherwise returnable.

Such appropriately rinsed containers should be stored in a safe place pending delivery to *drum*Muster collection centres on designated collection days.

More information can be obtained from the drumMuster website, www.drummuster.com.au or contact drumMuster on (02) 6230 6712 and from Agsafe-accredited resellers.

4.6.2 Pesticide rinsate waste

Pesticide rinsates can be generated from the rinsing of emptied pesticide containers and the washing out of spray tanks and spray equipment lines. The production and disposal of rinsates is of the greatest concern as this will potentially contain a range of contaminants.

Given the range of pesticide products and the range of chemicals and their different degradation pathways, it is recommended that advice be sought from the manufacturer of each chemical product on the appropriate methods for managing the waste from their products. It is not an option to discharge pesticides into the sewer. Pesticides will inhibit biological sewage treatment systems which can be problematic where biological treatment systems are used to treat domestic sewage and trade waste.

Burte (2000) has described several disposal methods that can be used including:

- **Evaporation pit:** relies on evaporation and UV degradation to degrade the pesticides in the rinsate. It is constructed with an impervious liner (e.g. HDPE). This has the potential to be a relatively unsightly and untidy facility and is the least preferred option.
- **Biodegradation:** some biological systems that use microbial action to treat pesticide residues are available. Other systems use UV degradation and composting to manage the waste. This facility requires an impervious surface, and must be roofed, and include a means of leachate collection. The final system uses only a compost heap to degrade the wash waters.
- **Rinsate spraying:** Rinsate spraying involves applying the rinsate water at no greater than the label rates and in accordance with label directions. The following points must be considered:
  - A large area is required to dispose of the rinsate, e.g. practice fairway. This allows maximum uptake and degradation of the pesticide.
  - As this is effectively pesticide use, records must be kept.
  - Rinsate must not be applied to saturated soils.
  - Soils ideally would have a high organic matter content to ensure maximum uptake and degradation of the pesticide.
  - A sampling program is recommended to ensure that there is no accumulation of pesticides in soils and groundwater. The process of disposing of rinsates is time-consuming. In fact, it may take longer than the application of the pesticide.
- **Rinsate as batch make-up water:** The use of rinsate water from previous sprayings is recommended by the DECC and the pesticide product label directions specify the rinsate that can be added to the next spray mix. The rinsate water is stored in individual containers in a bunded area to be used as batch make-up water when the pesticide is next used. Issues to consider using this procedure are:
  - Ensuring that the concentration of pesticide does not exceed the label rate.
  - Possible degradation of the product in storage and its effects on the new batch.
  - Amount of management required to ensure safe storage and handling.

CONSIDERATIONS FOR GOLF COURSES WHO WISH TO DISPOSE OF TRADE WASTE

- Identify waste streams
- Describe treatment facility (plans etc.)
- Demonstrate waste minimisation strategies including reuse and recycling
- Include analysis results for wastes generated
- Determine volume of waste
- Obtain and submit appropriate application forms
- Have a written waste management plan
- Have a staff training program for the operation of the treatment facility.

The specific requirements for each individual council must be established as part of the planning process.

4.7 DECIDING ON HOW TO DISPOSE OF WASTE GENERATED AROUND MAINTENANCE FACILITIES

In keeping with the philosophy of cleaner production, the overall approach should be to focus on eliminating waste rather than on how to dispose of the waste. Whenever an activity generates wastes, a decision must be made on how to eliminate or reduce the generation of such waste in future, what opportunities are available for on-site reuse or recycling, whether and how the waste will be treated, how extensive any treatment will be and where the treated or untreated waste will be disposed of.

Some waste can be pre-treated and disposed of as trade waste. This will often require investment in new technology and a change in management procedures. For washdown facilities, the best practice design is a facility that enables recycling of pesticide wash waters without generating secondary waste streams that are extremely hard and costly to manage (Burte 2000).

On more sophisticated facilities, sand and activated carbon filters are used to remove particulate matter and pesticides but the filters themselves will then require disposal as hazardous waste. It is also important to have a written management plan for the facility. The following checklist (Table 4.1) can be used as a guide in determining waste streams and options for treatment.

TABLE 4.1: Checklist — Waste Streams and Options for Treatment

	Grease, oils etc.	**Grass clippings**	**Wastewater from machinery washdown bay**	**Wastewater from spray tank filling facility**	**Rinsate from pesticide spraying**	**Pesticide waste**	**Pesticide container waste**
1. What wastes are generated?							
2. Quantity of waste currently stored?							
3. Where is waste currently stored?							
4. How is waste disposed of?							
5. Options • use on site • trade waste pick-up • recycle • compost • treat/discharge on site • licensed trade waste disposal • Industry scheme drumMUSTER, ChemClear.							

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SECTION FIVE

Fertiliser Practices

Contents

SECTION 5:
Fertiliser Practices

KEY CONCEPTS

- Nitrogen and phosphorus can adversely affect water quality through the stimulation of aquatic algae and weeds and degrading the water as a potable supply.
- Nitrogen is highly susceptible to being lost from turf areas through:
  - volatilisation;
  - leaching;
  - surface runoff; and
  - removal off-site through grass clippings.
- Phosphorus has low solubility and is principally lost from turf areas through the movement of soil particles.
- Phosphorus leaching can occur on soils with a low phosphorus retention index (eg. sandy soils), or with ongoing phosphorus loading that is in excess of plant requirements.
- Turfgrass systems have a high capacity to absorb and retain nutrients and prevent their loss to the wider environment.
- Reclaimed water containing plant nutrients can provide an alternative fertiliser source.
- The potential for nitrogen and phosphorus losses can be significantly reduced by:
  - using slow release fertilisers, and
  - fertilisation using 'spoon feeding'—that is, applying a little fertiliser often.
- Avoid fertilising if rainfall is expected.
- Use soil and plant tissue testing to monitor fertiliser requirement
- Use soil sensors to monitor soil nutrient levels and water application.

5.1 THE ENVIRONMENTAL IMPACT OF USING FERTILISERS ON TURF

The maintenance of golf courses relies on the well-regulated use of both fertilisers and water so that high-quality playing surfaces are produced. Lush, green and vigorously growing turf swards are undesirable for golf as these surfaces are usually soft, slow and prone to attack by insects and disease. Australian golf courses have traditionally been maintained to minimise inputs so that firm, fast and tight surfaces are produced.

5.1.1 Nitrogen losses from turfgrass systems

In turfgrass systems, nitrogen is generally of most importance from a water quality perspective (Walker and Branham 1992). Petrovic (1990) has provided the most comprehensive review on nitrogen losses in turfgrass systems and provides information on the development of best management practices to prevent groundwater deterioration. He stated that nitrogen will escape from local nutrient cycling systems in turfgrass through:

- gaseous processes including volatilisation from applied fertiliser and denitrification;
- leaching from the rootzone;
- surface runoff; and
- removing grass clippings off-site, potentially a significant source of nutrient loss from the turfgrass nutrient cycle.

Volatilisation

Ammonia volatilisation is known to occur rapidly following the application of urea (Bowman et al. 1987). The losses due to volatilisation cited by Walker and Branham (1992) have ranged from 10% to 39% in closed system experiments and from 9% to 41% in field experiments. The variation depends on climate conditions (e.g. higher volatilisation in hotter, low humidity conditions) and the irrigation method used (e.g. fine spray irrigation increases volatilisation). Other forms of nitrogen such as ammonium nitrate and sulfur-coated urea exhibit very little loss by volatilisation.

Denitrification

During soil saturation conditions, soil mineral N levels can be reduced by the conversion of nitrate N into gaseous N forms, N_2 and N_2O, which are lost to the atmosphere (Peverill, Sparrow and Reuter 1999).

Mineralisation

Organic N (in soil organic matter) is released to plants through microbial processes into mineral forms, predominantly ammonium (NH_4^+) and Nitrate (NO_3). Increasing the duration of moist and warm soil conditions will have varying affects on the opposing soil processes of mineralisation (transforming soil organic N into mineral N) and immobilisation (transforming soil mineral N into soil organic forms) and thus on net mineralisation of soil N (Peverill, Sparrow and Reuter 1999).

Leaching

The degree of nitrate leaching from turfgrass systems is variable (Petrovic 1990), depending on soil type, irrigation, nitrogen source and rate and time of year applied. Some researchers have reported little or no leaching while others have measured 80% or more of applied nitrogen. Walker and Branham (1992) compiled a table of the available research on nitrate leaching in turfgrass systems. It is important to note that many of the experiments were based on single and relatively high nitrogen applications, and in several of the studies the nitrogen applications are several times greater than what would be expected to be used on typical New South Wales golf courses.

Overall, the leaching losses and the nitrate concentrations were relatively low. However, one particular study showed significant leaching to a depth of 3 metres with nitrate concentrations in excess of 50 mg/L (Exner et al. 1991). The contributing factors causing this leaching were high irrigation applications (51 mm every third day) and a high nitrate concentration (10 mg/L) in the irrigation water. This study demonstrated the importance of not applying excessive amounts of water that leach the nitrate out of the root zone before turf uptake.

Environmental studies funded by the United States Golf Association (Snow 1996) reported in the USGA Green Section Record (Vol. 33(1), 1995). Yates (1995) demonstrated that on a sand/peat putting green, with nitrogen applied at 0.5 kg N/100 m^2/month, 0.56–1.69% of the applied nitrogen leached through the turfgrass. In a fairway situation, on a loamy sand soil with the nitrogen applied at 0.25 kg/100 m^2/month, the losses were 0.30–0.75%.

Brauen and Stahnke (1995) examined the leaching of nitrate on sand profiles where nitrogen was applied at 2, 4 and 6 kg N/100 m^2/year either monthly or every two weeks and found that application at 4 kg N/100 m^2/year resulted in little or no nitrate leaching.

The important contributing factors were:

- 70% of the nitrogen being in a slow release form;
- fertilising at 14-day intervals at reduced rates; and
- having a mature turf with a good root system and some accumulation of organic matter.

In a monitoring study of nitrate and pesticide leaching beneath golf courses on sandy soils at Cape Cod, Massachusetts, Cohen et al. (1990) observed nitrate concentrations in the groundwater ranging from 0.1 mg/L to 30 mg/L. Nitrate concentrations did not exceed the drinking water standard of 45 mg/L (10 mg/L nitrate-nitrogen). It was also found that subsurface losses of nitrogen were reduced when slow release fertilisers were used and application rates were reduced.

Irrigation practices are seen as having an important influence on the leaching of nitrogen. Various studies have been undertaken and where irrigation is uncontrolled and excessive, the leaching losses are generally high (Petrovic 1990). Conversely, where soil moisture sensors are used to monitor/control irrigation, the leaching losses are very low.

The other significant factor affecting leaching losses was the timing of fertilising. Leaching losses are increased during periods of cool weather and high rainfall. Cool temperatures in particular reduce plant uptake as well as reduce denitrification and microbial immobilisation. Fertilising before high rainfall events can result in large losses of nitrogen.

The transport of nutrients in surface runoff is a potential means for the movement of nutrients off-site. However, in the limited publications concerning runoff from turfgrass, nutrient transport was significantly reduced by turfgrass systems (Douglas et al. 1995). In trials undertaken on a sloping site (9–11% slope), with a nitrogen application rate of 4 kg N/100 m^2/year and subjected to an irrigation event of 150 mm/hr, there was little or no movement of nitrogen in the runoff water (Douglas et al. 1995). The key factor influencing surface runoff was turf density, where a dense turf consisting of a stoloniferous grass species increased the resistance to overland flow, increasing the opportunity for infiltration of water and trapping of nutrients in the thatch/organic layer. Concentrations of Nitrate-N and Kjeldahl-N rarely exceeded 7 mg/L and 2 mg/L respectively and generally the nutrient loadings reflected those found in the irrigation water.

5.1.2 Phosphorus losses from turfgrass systems

Phosphorus is essential for turfgrass health and growth, but if incorrectly applied or overused it can create environmental problems. Plant nutrients in waterways can initiate serious algal blooms and the growth of other aquatic weeds. While a range of factors contribute to nuisance algal and weed growth, they can occur with relatively low nutrient levels in the waterbody. ANZECC & ARMCANZ (2000) provides guidance and water quality criteria that can be used to assess the risk of adverse effects of nutrients. The risk of nuisance aquatic algae/plant growth is increased when ambient nutrient levels in the waterbody exceed the 'trigger values' given in Table 5.1. See ANZECC & ARMCANZ (2000) for guidance on the use of 'trigger values' and management of nuisance plant and algae growth in waters.

Table 5.1: Default ANZECC & ARMCANZ (2000) 'trigger values' for nutrient stressors for slightly disturbed aquatic ecosystems in NSW.

Ecosystem type	TP (mg P L^{-1})	FRP (mg P L^{-1})	TN (mg N L^{-1})	NO_x (mg N L^{-1})	NH_4^+ (mg N L^{-1})
Upland river	20	15	250	15	13
Lowland river[a]	50	20	500	40[o]	20
Freshwater lakes & Reservoirs	10	5	350	10	10
Wetlands	no data	no data	no data	no data	no data
Estuaries[p]	30	5	300	15	15
Marine	25	10	120	25	20

a = values are 3 μgL^{-1} for Chl a, *25 μgL^{-1} for TP and 350 μgL^{-1} for TN for NSW east flowing coastal rivers. TP = total phosphorus, FRP = filterable reactive phosphate, TN = total nitrogen, NO_x = oxides of nitrogen; H_4^+ = ammonium; DO = dissolved oxygen*

The movement of phosphorus in surface runoff is usually associated with the movement of soil particles. Most well-established golf courses have a solid vegetation (turf) cover that greatly reduces surface runoff and effectively eliminates soil movement. On construction sites or disturbed areas, management practices that minimise soil movement should be used. These include preventative measures as well as appropriately placed and maintained sediment controls such as sediment traps and barriers, and silt fences and straw bales. Buffers and sediment controls adjacent to waterways are particularly important to minimise potential impacts on surface water resources. For further information on sediment controls see NSW DECC (1998) *Managing Urban Stormwater: Soils and Construction* (the 'Blue Book').

The phosphorus sorption capacity of a soil relates the process by which phosphorus binds to the soil, thereby becoming unavailable for leaching or run-off. Different soil types have a varying capacity to sorb phosphorus. Sandy soils, for example, generally have a limited capacity to retain phosphorus. Once soils reach phosphorus saturation, any additional phosphorus (dependent on its form), may be leached deeper into the soil profile and the underlying watertable. The process of leaching starts to occur before the full P-sorption capacity of the soil is reached. Soil analysis, in particular measuring the phosphorus retention index (PRI), is used to indicate a soils P-sorption capacity. Measuring the PRI is desirable on sandy soils. Most soil test interpretations have a minimum phosphorus concentration that can often be at phosphorus saturation for that particular soil.

5.2 SOIL AND PLANT TISSUE TESTING

Soil and plant tissue testing is widely used in turf management for several purposes (Carrow 1995):

- identifying nutrient deficiencies;
- predicting nutrient needs for adjustment by fertilisation;
- evaluating potential excesses or imbalances of essential nutrients, heavy metals or salts;
- assessing other important soil chemical aspects such as pH, organic matter content, salt status and cation exchange capacity that may influence turfgrass growth; and
- environmental monitoring.

Annual soil and tissue testing provides a very useful means of fine-tuning the fertiliser program and determining the effectiveness of amendments that have been made previously.

The elements normally tested in soils include pH, electrical conductivity (salinity), phosphorus, potassium, and exchangeable cations (calcium, sodium, magnesium and potassium). While micronutrients can also be tested for, their relevance to plant uptake is questionable.

Plant tissue analysis provides an excellent complement to soil testing and gives the best indication of plant-available nutrients, particularly micronutrients. Where controlled release fertilisers are used, particularly potassium, soil tests can often give unexpected, low results.

As the controlled release nutrient is released to meet plant requirements, there is little excess nutrient to be adsorbed onto the soil particles; consequently, the nutrients often show up to be excessively low. On the other hand, in the same situation, plant tissue analysis often indicates adequate amounts of nutrients in the plant and therefore completes the soil–turfgrass relationship.

Plant tissue analysis usually includes analysis for nitrogen, phosphorus, potassium, calcium, magnesium, sodium, chloride, sulfur, manganese, boron, copper, zinc and iron.

The application of nutrients and soil amendments has become a refined maintenance practice and is used to produce firm, fast, high-quality golfing surfaces. Soil and plant tissue testing is a worthwhile investment to manage the fine edge between high-quality surfaces and turfgrasses that are weak, lack density and are susceptible to disease.

THE VALUE OF SOIL AND PLANT ANALYSIS

In looking at the average fertiliser use on greens and fairways, the costs (including labour, materials and equipment) are about $25,000–35,000 p.a. If soil and plant tissue samples were taken from three representative greens and fairways (i.e. 6 soil tests and 6 plant tissue analyses), the cost would be about $1,056. The cost of testing is therefore about 3–4% of cost of the fertiliser program. This is a relatively small cost if you consider:

- the cost of an unnecessary or inappropriate fertiliser application;
- the fact that analysis is an integral part of the integrated pest management program;
- that good turf nutrition results in good, healthy turf that requires fewer pesticides. One less application of fungicide would cover the cost of the testing program; and
- that analysis provides a method for monitoring salts and sodium where low-quality water is used. Early diagnosis of high salinity and sodicity allows for appropriate treatments to be initiated to prevent turf damage and costly renovations/rejuvenation.

5.3 SOURCES OF NITROGEN FERTILISER

Nitrogen sources can be divided into two categories: readily available (high solubility) and slow release (low solubility) sources. Soluble nitrogen sources are highly susceptible to leaching losses. On sandy soils or sites that have a shallow watertable and sites with geologic pathways to the groundwater from cracks, rocks or high pedality, nitrogen leaching beyond the root zone and into the watertable is a greater risk. Controlled release fertilisers have been used to reduce these losses.

Inorganic salts: Applications of inorganic salts (e.g. ammonium nitrate) to turfgrasses usually produce a rapid initial flush of growth of short duration. In the absence of large leaching or volatilisation losses, the efficiency of uptake is relatively high, however, within three weeks after application, up to 20–30% of the applied N can still be recovered from the root zone (Turner and Hummel 1992). This indicates that there is still opportunity for leaching losses to occur. On putting greens with high sand content, the technique of ‘spoon feeding’, which provides very low application rates of nutrients, is often used. This procedure encourages consistent growth patterns and greatly minimises losses due to leaching.

Slow release: There are several forms of slow release fertilisers, including organics, synthetic organics and coated fertilisers.

Natural organics include a range of products such as animal manures and activated sewage sludges. Processed poultry manure has been a popular form of organic fertiliser and contains about 3–5% nitrogen. Organic fertilisers are slow release in nature and rely on the release of nitrogen by microbial breakdown of the complex organic molecules; however, the release rate is relatively unpredictable.

Synthetic organics include urea formaldehyde reaction products and isobutylidene diurea (IBDU). Urea formaldehyde is typically marketed with a portion of nitrogen that is water-soluble and causes a quick response in the turfgrass. IBDU has very little soluble component and may take some time to initiate a response. It is very important when selecting slow or controlled release fertilisers that the turf manager understands the responses to quick and slow release forms of nitrogen.

Coated nitrogen sources are made by coating urea or other soluble nitrogen sources with a semi-impermeable coating. Sulfur is frequently used, often with a polymer or resin coating. Sulfur-coated urea is a very effective fertiliser and has proven to be cost-effective on 'broadacre' turf.

The release rate for controlled release forms of nitrogen is affected to varying degrees by temperature, moisture and microbial activity. It is therefore important that the turf manager understands the fertiliser–environment interactions so that the desired outcomes are achieved.

As a proportion of the golf course, the fairways represent the greatest potential for nitrogen losses through leaching. Fairways are fertilised infrequently, usually with relatively high quantities of nitrogen. It is not convenient or cost-effective to 'spoon feed' fairways unless fertigation is used. However, the use of inorganic forms of nitrogen makes fairways susceptible to leaching losses if a high rainfall event occurs soon after application. Neylan and Robinson (1997) demonstrated that on sand profiles an inorganic nitrogen source was depleted within five days of application following heavy irrigation. In this situation, the nutrients were leached directly into the watertable.

Because of the leaching potential and possible environmental impacts, there is a justification for using controlled release fertilisers on sand-based fairways in conjunction with other irrigation management practices such as controlling the leaching fraction with irrigation scheduling and soil moisture sensors.

Advantages of controlled release fertilisers are:

- that less frequent applications are required;
- that leaching losses are reduced; and
- they promote more even growth patterns.

Perceived disadvantages of controlled release fertilisers are:

- their high cost; and
- lack of longevity of some products under tropical conditions.

5.4 FERTIGATION

Fertigation involves injecting nutrients into the irrigation system at controlled, low concentrations. This allows for the ‘spoon feeding’ of large areas of turf while greatly reducing labour and equipment costs. It also allows the turf to be fertilised at night and therefore reduces the inconvenience to golfers.

Because of the water quality on many golf courses, in particular high sodium, gypsum injection into the irrigation system is common. The equipment permits the addition not only of gypsum but also of various fertilisers and wetting agents.

CASE STUDY: Cost/Benefit Analysis of Fertigation

The following case study is a cost/benefit ananlysis comparing the use of fertigation as a method of fertilising and applying soil amendments.

1 Fertiliser application

Fertiliser:	Potassium nitrate
Area:	20 ha
Labour:	Using injection system — 1.5 hours
	Application by conventional spreader — 6 hours
Labour cost:	Injection system — $1.50/ha
	Conventional — $6.00/ha
Machinery cost:	Conventional — $50.00/ha

Potential benefit is $54.50/ha/application. If 4–6 applications are made over a year, the benefit is $218–327/ha or $4,360–6,540.

2 Gypsum application

Premium grade fine gypsum for injection system:	$420/tonne
Application rate:	5 t/ha/year
Cost of applying gypsum through injection system:	$2,100/ha
Area:	20 ha
Total cost:	$42,000
Conventional supply and spread to apply gypsum at 5 t/ha	$250/ha
Total cost	$5,000

The gypsum injection unit costs about $17,000. Based on using it for fertilising, the payback period is 2.6–3.9 years.

There is a direct economic benefit to be gained from using the injection system for gypsum applications on fairways, as well as other benefits:

- greater efficiency of application. Soluble gypsum reacts more quickly and moves deeper into the profile;
- the system allows small quantities to be applied often, improving the reaction in the soil and counteracting the regular applications of sodium in the water;
- no large machinery is used on the golf course; and
- no golfer complaints are received about gypsum on the turf.

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SECTION SIX

Grass Selection

Contents

SECTION 6:
Grass Selection

KEY CONCEPTS

- There is no perfect grass for all situations.
- Each situation must be assessed in terms of climate, soil, budget, maintenance etc.
- Any new grasses must be thoroughly evaluated through both independent trials and on-site trials.
- At least three to five years of evaluation is required.

6.1 INTRODUCTION

Turfgrasses maintained as golfing surfaces represent a very intensive form of horticulture, requiring moderate to high inputs of water, fertiliser, energy (mowing) and plant protection chemicals. However, as the golfing industry becomes more environmentally aware, it is trying to reduce these inputs and find turfgrasses that can survive with lower inputs while still providing good golfing surfaces.

Water is possibly the single biggest issue that will affect golf course management in the future, with increased use of high-salinity water and potential restrictions on water supplies a worldwide trend. There is an urgent need to develop grass species and cultivars that have lower water use, increased drought tolerance and improved salinity tolerance. This will provide significant environmental benefits in reducing the use of high quality potable water and also the potential for run-off.

While new, environmentally acceptable cultivars are being developed, plant-breeding programs are also striving to improve the surface characteristics of turfgrasses to provide better golfing surfaces. While significant advances have been made in the quality of grass varieties for greens, these varieties also appear to require a more intensive maintenance regime.

New South Wales has a range of climates where both cool-season and warm-season grasses can be successfully grown or in many situations a combination of both.

6.2 COUCHGRASS SELECTIONS FOR GOLF GREENS

Tifdwarf (Tifton 419) and *Tifgreen* (Tifton 328) are the predominant grass types used on golf greens. In recent years, golf courses in the USA have been replacing *Tifdwarf* and *Tifgreen* with one of several new ‘dwarf’ couchgrass cultivars. The reasons for the change are:

- contamination with off-types that disrupt the uniformity of the putting surface;
- requirement for increased putting speeds (need for cultivars that tolerate lower cutting heights); and
- significantly improved new cultivars.

Trials in the USA have compared the performance of *Tifgreen* and *Tifdwarf* with that of *Baby, Champion*, *Floradwarf, Miniverde, Mobile, Tifeagle* and other 'TIF' cultivars (White 1999). The results of the trials to date indicate that:

- turf quality is best at about 4.5 kg N/100 m²/yr;
- *Tifdwarf* exhibited the greatest response to increasing nitrogen (up to 6.3 kg N/100 m²/yr);
- *Floradwarf* turf quality was lower than that of *Champion*, *Miniverde*, *Tifeagle* and *Tifdwarf*, mainly due to an adverse response to high sodium and high pH levels;
- many of the new dwarfs accumulate thatch more aggressively than *Tifdwarf*. The thatch accumulation was, on average, five times greater for *Champion, Floradwarf, Miniverde* and *Tifeagle* than for *Tifdwarf* at a nitrogen rate of 2.7 kg N/100 m²/yr; and
- regular verticutting and topdressing are required on the new dwarfs, where severe, infrequent verticutting adversely affects the turf quality.

Texas research (White 1999) posed the question as to whether the new dwarf couchgrasses are superior. The research is not conclusive and, as with most other similar trials (e.g. NTEP 1999), the cultivars need to be evaluated over several years. The greatest attribute of the new grasses is their high density at very low cutting heights when compared to *Tifdwarf*. However, they require frequent mowing at low cutting heights ($\leq$3mm). The golf course must have a budget that allows for:

- regular, low cutting with walk-behind mowers
- regular verticutting, and
- regular topdressing (dusting).

Golf courses that do not have the resources are advised to carefully consider whether to establish the new dwarf couchgrasses in preference to *Tifdwarf* or *Tifgreen*.

In northern New South Wales golf greens, *Tifdwarf* and *Tifgreen* have experienced some problems, particularly with the incidence of diseases during summer stress. While it is attractive to consider the introduction of new 'wonder' grasses, this should be done only after careful local assessment. In the USA, the United States Golf Association (USGA), Golf Course Superintendents Association (GCSAA) and the National Turfgrass Evaluation Program (NTEP) are sponsoring couchgrass trials on golf courses (Anon. 2000). *MSsupreme*, *Tifeagle*, *Miniverde*, *Champion* and *Floradwarf* are being compared to *Tifdwarf* and *Tifgreen* at eight golf courses. This on-site testing program is designed to provide scientific information of a more applied nature about the performance of putting green couchgrass cultivars. The trials are designed to run for five years.

The important requirement is that these new cultivars undergo rigorous assessment in organised, replicated trials and on-course trials before any of them are introduced into New South Wales golf greens. The economic ramifications could be significant. Taking into account the additional mowing, verticutting and topdressing requirements, the increase in maintenance costs is estimated at about $240–350/100 m²/yr.

6.3 BENTGRASS SELECTION FOR GOLF GREENS

Bentgrass has long been considered the premier grass for putting greens with *Seaside* the first of the selected and named varieties released in 1923 (Reese, 2000). The next significant improvement occurred in 1955 with *Penncross* and then *Penneagle* in 1979. Since the mid 1980's there have been many new varieties released, with the current new types having been released to the market about 1995.

The breeding programs have had different objectives in terms of turf characteristics. Bentgrasses are most commonly selected for: greater turf density, reduced spiking, lower cutting height, increased salt and heat tolerance and increased disease resistance. The most obvious changes in characteristics have been in turf density and vigour. While the bentgrasses have become more dense and produce smoother and faster putting surfaces, they require more frequent cutting, dusting and thatch removal.

The Australian Golf Course Superintendents Association (AGCSA) has established a bentgrass variety evaluation trial at Kingston Heath Golf Club (VIC) and Glenelg Golf Club (SA) with a site to be established New South Wales in 2002. The objective of the trials is to assess the growth and performance characteristics of the new bentgrasses under local conditions.

In the absence of Australian data, a review of the data from the United States of America and more specifically, from the National Turfgrass Evaluation Program (NTEP), National Bentgrass Test – 1998 (Putting Green) program (NTEP, 2000) has been done. The NTEP program provides a detailed assessment of many turfgrass varieties, including bentgrass, over numerous sites throughout the USA. The bentgrass trials were established in 1998 and the results that follow are from the 2000 progress report. For convenience, only those varieties that are of interest in Australia are discussed. The full tables are available through the AGCSA or on www.ntep.org (the NTEP web site).

Turf Quality

The mean turfgrass quality of bentgrass cultivars grown at 24 locations in the NTEP trials, provides an average quality over all locations. While this does not provide specific location results, it does provide a good indication of the adaptability of the cultivars. Over the 24 sites, *Penn A4* was the top ranking cultivar with *Penn A1, Penn G1, Penn A2, L-93* and *Penn G6*, marginally below *Penn A4* but were of a similar ranking to each other. *Providence* was ranked significantly below all these varieties with *Penncross* and *Pennlinks* amongst the lowest ranking varieties.

The mean turfgrass quality ratings for each month indicate a similar trend, with the *Penn A* and *G* series and *L-93* being the dominant summer varieties. There were less significant differences between all varieties during the winter months.

At three sites the bentgrasses were maintained without fungicides and these results show that *Penn A1, Penn A2* and *L-93* all rated very highly. *Providence, Crenshaw* and *Penncross* were at the lower end of the ratings.

In trials conducted on 13 golf courses as part of the NTEP program, *Penn A4* was the top ranked variety, with the other *Penn A and G* series bentgrasses and *L-93* also amongst the top rated bentgrasses (Kind, 1999).

Summer Survival

'Summer Survival' has been determined in the NTEP trials by assessing the percentage of living ground cover during the summer months. 'Summer Survival' is of interest both in Australia and the USA as bentgrass is introduced or maintained in many marginal climatic zones where it is under stress from high temperature and humidity.

The results for percent living ground cover over four sites show that *Pennlinks, Providence, Crenshaw, Penncross, Penn G1, Penn A2* and *L-93* were amongst the top ranking cultivars.

Summer density ratings were also recorded with *SR7200* (Velvet Bent), *Penn A1* and *Penn A4* in the top group. *Penn G1, L-93, Penn A2, Crenshaw* and *Penn G6* made up the next grouping with *Penncross* and *Pennlinks* having the lowest summer density.

Thatch

The new bentgrass cultivars have a very high shoot density, an upright growth habit and vigorous growth that can result in rapid thatch accumulation. As improvements have been made in the bentgrass cultivars, such as greater density and more vigorous growth, the downside has been the increased production of thatch. At two sites where thatch depth was measured, the *Penn A and G* series and *SR7200* were in the top group for greatest thatch depth whereas the cultivars *L-93, Crenshaw* and *Penncross* were ranked amongst the lowest thatch producers.

It is very important to note that from a point of sustainability, it is not going to be possible to introduce these improved varieties without implementing a more vigorous program of thatch control. The improved varieties require more regular mowing and frequent topdressing (dusting) and golf courses contemplating their introduction must take this into consideration.

Disease Tolerance

Anecdotal evidence in Australia would suggest that the incidence of diseases such as 'Brown Patch' (*Rhizoctonia sp.*) and *Pythium sp.* increased with the introduction of cultivars such as *SR1020* and *Providence*, when compared to *Penncross*. This has always been attributed to the greater shoot density and less than ideal thatch control techniques which combine to create a microclimate more conducive to the development of disease.

Most new cultivars are selected for improved disease tolerance as a genetic trait. However, the environment will override any in-built advantages if the maintenance practices are less than ideal.

In the NTEP program, Dollar Spot, Brown Patch, Microdochium and Pythum Blight have been reported at some locations. *Penncross* was the cultivar most affected by Microdochium, with *Penn A2, Penn G6* and *Providence* affected more than *L–93. Penncross, Pennlinks, Penn A1, L-93* and *SR7200* were the least affected by Dollar Spot, with Providence and Crenshaw being the most affected. The incidence of Brown Patch was lowest on SR7200, with *L-93, Penncross, Crenshaw* and *Penn G6* being slightly more affected. The cultivar *SR7200* was in a category of its own, exhibiting almost no incidence of Brown Patch.

Pythium Blight was noted at only one site with most varieties exhibiting a very low incidence of Pythium Blight. The variety *Bavaria* (velvet) was significantly more affected than all other cultivars.

At one site in the NTEP trials the incidence of Dollar Spot was recorded where no fungicides were used and the results show that *Crenshaw* was the most affected, with *SR7200* and *Bavaria* being virtually unaffected. *Penn A1, Penncross, Penn A2, Penn G6, Penn A4* and *Penn G1* were amongst the least affected.

Management

The new bentgrass varieties have been in the market place for some time and superintendents are now undertaking their own assessments. Robinson (1998) stated that *Penn A4* required regular low mowing to improve playing quality and health due to high turf density. His program included cutting at 2.5mm and over 12 months double cutting on 169 occasions and single cutting 93 times. In addition, the greens were regularly rolled and dusted (lightly topdressed) on 30-35 occasions. Dusting also presented a challenge in brushing the sand through the dense turf layer, with particles greater that 0.5mm remaining on the surface. Dusting was done almost weekly using a mechanical brush to 'work' the sand in. The program also involved monthly applications of wetting agent to prevent the occurrence of dry patch.This superintendent made cost comparisons with *Penncross* and found that the cost of greens management was \$US714 /100m^2 for *Penn A4* compared to \$US615/100m^2 for *Penncross*. The main advantage for the *Penn A4* was the consistently high green speeds (> 3.34 metres) and strong competition against *Poa annua* invasion.

A survey of golf clubs that had established new bentgrass cultivars indicated that thatch control was the main concern and that low mowing (2.4 - 3.6mm) was essential with the mowing frequency being from five times per week to daily double cutting at one club (Fraser, 1998). The average stimpmeter reading was 3.05m (10 feet). The report concluded that the new bentgrasses require different management, will perform well in a range of geographic environments and need an aggressive management program (e.g. low mowing).

Salt Tolerance

Marcum (2000) has studied the salt tolerance in the modern bentgrass varieties where he tested 35 bentgrass cultivars, with increasing salinity concentrations from 1 decisiemans/metre/day up to 8 dS/m/metre/day at which time data was collected. The most salt tolerant cultivars were *Mariner, Seaside II, Grand Prix, Seaside, 18th Green* and *Century.* The least tolerant cultivars suffered complete death after ten weeks exposure and they included *Avalon* (velvet bent), *Ambrosia* (colonial bent) as well as *Regent, Putter, Penncross* and *Penn G-6*.

6.4 GRASS SELECTION FOR FAIRWAYS

The National Turfgrass Trials in Australia (Neylan and Robinson, 1997) demonstrated that there was a significant difference in the performance of the couchgrass cultivars used on New South Wales golf courses, with the varieties *Legend, Windsorgreen* and *Santa Ana* having the highest performance index. There are other new couchgrass cultivars available, such as *Plateau* and *Conquest* that have potential and in particular *Plateau*, which has demonstrated very good shade tolerance. As with all new turfgrass varieties they must be subjected to rigorous evaluation before they are widely adopted.

6.5 TURFGRASS WATER USE

The area of most interest in relation to turfgrasses is in determination of their water use rate and selection of cultivars with a high water use efficiency. Beard and Sifers (1989) have demonstrated that the warm-season grasses have the lowest water use rate, the best drought tolerance and highest recovery, compared to the cool-season species.

Within the warm season species, some differences between cultivars have been observed, but in practical terms these would appear to be very limited. Research in Western Australia (Colmer et.al. 2001) demonstrated that the maximum daily irrigation required to maintain growth and colour ranged from 50–60% net daily evaporation (Epan) for nine warm season turfgrass genotypes to 80–100% for two cool season turfgrass genotypes. For example, ryegrass was almost twice that of *Wintergreen* couchgrass (Table 6.1). The differences in water use rates and irrigation requirements among the warm season grasses were relatively small and not statistically different.

Table 6.1: ET values for various genotypes measured in field lysimeters. Different letters in the same column indicate significant differences at the 5% level.

Turfgrass genotype	ET (days with 5-8 mm of Epan) (% Epan)	ET (days with 8-11 mm of Epan) (% Epan)
Cynodon dactylon ‘Wintergreen’	59.8 (± 2.1) [a]	51.9 (± 1.6) [a]
Paspalum vaginatum	63.9 (± 2.4) [a]	53.8 (± 1.5) [a]
Stenotaphrum secundatum	67.8 (± 2.4) [a]	55.4 (± 1.6) [a]
Pennisetum clandestinum	65.8 (± 2.1) [a]	55.4 (± 1.0) [a]
Zoysia spp.‘ZT94’	66.5 (± 3.2) [a]	52.3 (± 1.9) [a]
Festuca arundinacea ‘Arid’	95.5 (± 4.7) [b]	87.7 (± 3.0) [b]
Lolium perenne ‘Accent’	102.1 (± 4.4) [b]	90.0 (± 5.8) [b]

This research would indicate that there is no advantage in changing between warm-season species/cultivars for the purpose of conserving water. However, the conversion from cool-season grasses to a warm-season species has considerable potential in saving water.

6.6 SEASHORE PASPALUM

Seashore paspalum (*Paspalum vaginatum*) has the potential to be one of the most environmentally compatible turfgrasses (Duncan 1996, Duncan and Carrow 1999). It is reported that seashore paspalum will grow with:

- minimal pesticide applications;
- about 20–40% of the annual fertiliser that is applied to hybrid couchgrasses;
- a soil pH of 4–9.8;
- an ability to act as a bioremediant on contaminated sites;
- high-salinity water (on some cultivars up to 14 000 mg/L of sodium chloride);
- drought resistance equivalent to that of couchgrass;
- moderate shade tolerance (up to 35% light reduction); and
- a good tolerance of periodic inundation due to heavy rains or high tides.

Limitations in the use of seashore paspalum relate mainly to its lack of cold hardiness. The earlier selections were killed at –8.0°C, although several ecotypes have survived at –16°C. The other concern with this species is its tolerance of certain insect pests (e.g. mole crickets and army worm) and fungal pathogens (Curvularia, Pythium and Dollar Spot). The research to date has revealed several selections that have exhibited resistance to most of these pests.

Seashore paspalum would appear to have excellent potential on:

- salt-affected soils, and
- areas where only high-salinity water (particularly recycled water) is available for irrigation.

In the short term, the new cultivars of seashore paspalum are not available in Australia; however, when they are introduced they will require intensive assessment to ascertain where they fit into New South Wales golf courses and also what management regimes they will need.

6.7 TURFGRASS PERFORMANCE INDICATORS

Each golf course has its own specific characteristics in terms of soils, climate, microclimates, water quality, maintenance facilities, golfer expectations and budget. In selecting suitable grass types it is often useful to go through a checklist of requirements to assist in making the most appropriate selections. The following table (Table 6.2) can be used as a checklist to identify local conditions, turf requirements and turfgrass suitability.

Table 6.2: Turfgrass performance indicators and selection criteria

1 Turfgrass situation ____________________________
(e.g. green, tee, fairway, rough)

2 What are the five critical requirements for each turfgrass situation?
(i.e. green, tee, fairway or rough)

List in order of priority:

(i) ____________________________

(ii) ____________________________

(iii) ____________________________

(iv) ____________________________

(v) ____________________________

3 What are the site conditions?

•	Soils ____________________________			
•	Water quality	**High**	**Moderate**	**Low**
	Salinity	☐	☐	☐
	Sodium	☐	☐	☐
	Bicarbonate	☐	☐	☐
•	Water availability	☐	☐	☐
•	Is shade a factor?		☐ Yes	☐ No
•	Is air movement a factor?		☐ Yes	☐ No
•	Climatic conditions		**Summer**	**Winter**

Average maximum temperature	______________	______________
Average minimum temperature	______________	______________
Average rainfall (mm)	______________	______________
Average evaporation (mm)	______________	______________

	Summer	Winter
Estimated ET (mm)	______	______
Average humidity	______	______
Average number of daylight hours	______	______

- Common pest problems: (List)

  ____

  ____

  ____

4 What resources are available for maintenance?

	High	Moderate	Low
• Labour	☐	☐	☐
• Equipment			
Mowers	☐	☐	☐
Dethatchers	☐	☐	☐
Sprayers	☐	☐	☐
Renovation equipment	☐	☐	☐
Topdressing machine	☐	☐	☐
• Budget	☐	☐	☐
• Irrigation system	☐	☐	☐

5 Sources of information on grasses

- National Turfgrass Evaluation Program (NTEP) ☐
- Horticultural Research and Development Corporation (HRDC) ☐
- Australian Golf Course Superintendents Association (AGCSA) ☐
- USGA Greens Section
- Golf Course Superintendents Association of America (GCSAA) ☐
- Australian Turf Producers ☐

6 Are the preferred turfgrass varieties available in Australia?

Selection	Yes	No
(i) ____________________	☐	☐
(ii) ____________________	☐	☐
(iii) ____________________	☐	☐
(iv) ____________________	☐	☐
(v) ____________________	☐	☐

7 What local evaluations have been undertaken?

____

____

8 What have been the results? (Obtain trial data.)

____

____

9. For any new grass types, and taking in account all available information, what improvements could be expected in the key requirements (see question 2) compared to the ‘conventional’ choices. Express as a percentage (%).

____

____

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SECTION SEVEN

Soil Management

Contents

This chapter addresses two key aspects of soil management on NSW golf courses: soil erosion and acid sulfate soils. Other elements of soil management are covered elsewhere in this manual, including fertiliser practices and water management. The full range of potential soil management issues for golf courses should also be considered, including soil fertility and nutrient management, soil structure, waterlogging and drainage, acidification, irrigation and dryland salinity, soil contaminants and healthy soil fauna/ microbial activity**.**

SECTION 7:
Soil Management

KEY CONCEPTS

Soils and soil structure provide the foundation for high-quality turf.

Poor management of soils can result in:

- loss of valuable topsoil;
- erosion;
- exposure of acid sulfate soils;
- loss of organic matter;
- siltation of water bodies;
- excessive compaction, dispersion or waterlogging;
- long-term maintenance problems; and
- poor or uneven turf growth

Site evaluations are critical in the planning of any new works that involve soil disturbance.

7.1 INTRODUCTION

Golf courses are constructed on a wide variety of soil types, ranging from sands to marine clays. Consequently, each site will have conditions peculiar to the site, which will impose special management requirements.

Identifying the soils on the site is the first step in developing an appropriate management plan. Many golf courses are disturbed sites where soils have been moved around to shape and contour fairways. If particular care has not been taken in the construction of the course and placement of these soils, the results can be:

- erosion;
- run-off of sediments to water ways and consequent siltation;
- impacts on aquatic life can lead to fish kills;
- severely compacted soils;
- topsoils lacking in organic matter;
- shallow topsoil layers;
- high salinity; and/or
- variable pH.

The construction stage is the ideal time to undertake any remediation required to improve the structure, water-holding capacity or drainage of the soils. This is done through:

- addition of gypsum to soils with high clay content or high exchangable sodium percentage;

- addition of organic matter to sandy soils;
- careful stockpiling of topsoils for later replacement;
- shaping profiles to assist in surface drainage; and/or
- installation of supplementary pipe drainage.

Where there is development of new sites and construction activities on existing sites in coastal areas, care needs to be taken with respect to the disturbance of acid sulfate soils (ASS). The disturbance of acid sulfate soils causes the release of sulfuric acid that acidifies water bodies, causes the death of aquatic life and corrodes concrete structures.

Compaction is a major concern on any construction site due to machinery operation and soil disturbance. Compacted layers have low infiltration rates; this will result in water runoff during irrigation, in turn resulting in wasted water and stressed areas of turf. Well-aerated soils encourage strong, vigorous root systems and healthier turfgrasses that require less water and fertilisers and are more resistant to pest attack.

On sandy soils, nutrient and moisture retention is very low; management strategies should include the addition of organic matter to improve both water and nutrient retention. This results in improved water conservation and lower fertiliser applications.

7.2 SOIL EROSION

Well-established golf courses have a dense vegetation cover that is highly resistant to erosion. However, during the construction phase, golf courses will often have large areas of land that are devoid of vegetation cover and are highly susceptible to erosion.
The extent of erosion can be minimised by careful management and the use of protective materials. It is important to consider methods of controlling erosion at the time of planning a project for the following reasons:

- erosion is harder to eradicate once it starts;
- erosion can lead to heavy sediment flow that contaminates waterways; and
- the soil that is lost may be valuable topsoil, which is costly to replace.

The environmental considerations of soil erosion are extremely important and major projects will require appropriate controls such as the development of Erosion and Sediment Control Plans. Erosion management should adopt the principles and management practices published in the NSW Department of Housing (1998) (The ‘Bluebook’) *Managing Urban Stormwater - Soils and Construction.* The NSW Department of Planning have prepared a brochure on preparing Erosion and Sediment Control Plans.

Another factor to consider is the long-term management of sites where valuable topsoil has been lost due to erosion. Topsoil takes hundreds of years to develop and contains the ‘living’ fraction of the soil that makes growing and maintaining turfgrasses so much easier. Topsoil contains organic matter, microbes and essential nutrients that are impossible to replicate with ‘artificial’ additions.

GENERAL STRATEGIES FOR EROSION CONTROL

- Minimise bare or disturbed areas.
- Where practical, break down the project into stages to keep earthworks areas as small as possible.
- Schedule works to ensure that erodible areas are stabilised as quickly as possible.
- Installing proper erosion and sediment control devices (sediment fences etc.)
- Limit damage via water flow by planning earthworks for the drier part of the year.
- Make sure that overland flows are diverted away from bare areas.
- Where water flow over bare areas is anticipated it should be slowed as much as possible by:
  - reducing the steepness of slopes;
  - diverting water off bare steep slopes (e.g. unsealed roads) into vegetated areas;
  - installing contour drains to intercept overland flows; and
  - leaving some vegetation strips.
- Avoid changing any natural watercourses during construction as this will speed up the flow of water and encourage erosion.

7.3 ACID SULFATE SOILS

Acid sulfate soils (ASS) are generally found in low-lying areas along the coastline, estuaries and estuarine floodplains throughout New South Wales, particularly in wetland areas. 600,000 hectares of ASS have been identified in NSW, including extensive deposits in the Tweed, Richmond, Clarence, Macleay, Hunter, Hawkesbury - Nepean and Shoalhaven catchments, Newcastle Harbour, and Tuggerah Lakes.

It is not practical to determine where all ASS deposits occur within the complex coastal soils. However, for planning purposes, areas of high risk have been identified and the NSW Department of Land and Water Conservation (DLWC) (now the Department of Water and Energy) has mapped ASS risk at 1:25,000 scale as part of the Resource and Conservation Assessment Council (RACAC) resource inventory program.

An Acid Sulfate Soils Management Advisory Committee has also been established to:

- advise government on the management of acid sulfate soils.
- coordinate research and management initiatives of government agencies.
- develop generic guidelines and principles for effective management at a local level.

Detailed information on ASS management is available in the *NSW Acid Sulfate Soil Manual* (by Stone, Ahern and Blunden, 1998) which superintendents should use to manage a landscape that has a high probability of ASS problems. Contact numbers for further information and/or to obtain copies of the manual are provided in the References and Further Reading Section and ASSMAC contacts.

The ASS Manual enables a proper assessment of the acid sulfate soil status of the site, the likely impact of the development on these soils and the options for managing these impacts. It also helps councils and others in assessing development applications on sites potentially affected by acid sulfate soils.

The following information on acid sulfate soils was adapted from Larsen and Graham (2000) and Stone, Ahern and Blunden (1998).

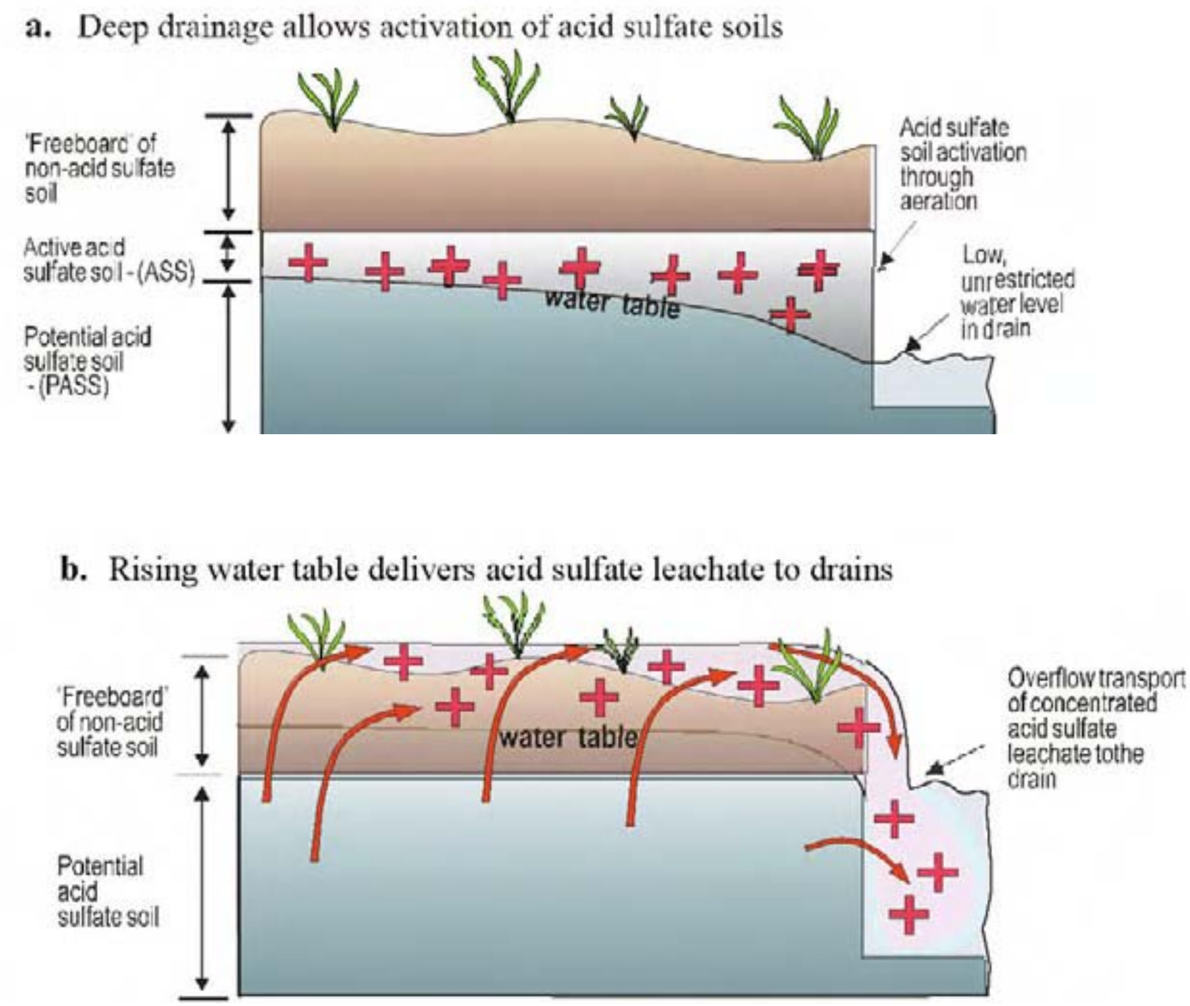
7.3.1 Disturbance of acid sulfate soils

Acid sulfate soils (ASS) occur naturally in low-lying coastal areas. These sediments were formed during the last major phase of coastal deposition between ~9000 and 2000 years ago, coinciding with the completion of the last great sea level rise. They commonly occur in areas with elevations of less than 5 metres above mean sea level and are often blanketed by a 1–2 metre surface cover of alluvial soil or dune sand. This surface cover generally has little or no acid sulfate potential and is commonly referred to as the ‘freeboard’.

Natural biological and chemical processes during deposition of these sediments result in there being rich in iron sulfides, particularly pyrite (FeS_2). Acid sulfate activation occurs when they are exposed to air, either directly by excavation or indirectly by drainage lowering local watertables (Fig. 7.1). When exposed to air the sulfides oxidise, producing sulfuric acid with pH levels commonly less than 1 (equivalent to car battery acid), iron flocs and often solubilised aluminium. These products build up in the soil and are released in high, often toxic concentrations to nearby waterways after rain, causing the death of fish and other aquatic organisms, as well as corrosion of concrete structures. Soil structure, soil arability and plant growth can also be impacted by acid runoff.

If the surface ‘freeboard’ layer is thin, ASS products may rise to the surface and cause surface scalds — patches of stunted and/or dead vegetation.

Figure 7.1: Formation of acid sulphate soils (adapted from Larsen and Graham (2000) and Stone, Ahern and Blunden ,1998).



7.3.2 Acid sulfate indicators

A number of indicators suggest that disturbance of acid sulfate soils is possible or has already occurred. Indicators that may be used in a preliminary assessment include those listed in Table 7.1.

Table 7.1: Deciding if acid sulfate soils are present based on soil or water field indicators

Soil type	Indicators
acid sulfate soils	**Landscape characteristics** • dominance of mangroves, reeds, rushes and other marine/estuarine or swamp-tolerant vegetation • low lying areas, back swamps or scalded/bare areas in coastal estuaries and floodplains • sulfurous smell after rain following a dry spell or when the soils are disturbed
actual acid sulfate soil	**Soil characteristics** • field pH < ≤4 in soils (see Appendix 1) • presence of shell • any jarositic horizons or substantial iron oxide mottling in auger holes, in surface encrustations or in any material dredged or excavated and left exposed. Jarosite is a characteristic pale yellow mineral deposits which can be precipitate as pore fillings and coatings on fissures. In the situation of a fluctuating watertable, jarosite may be found along cracks and root channels in the soil. However, jarosite is not always found in actual acid sulfate soils. **Water characteristics** • water of pH < 5.5 in adjacent streams, drains, groundwater or ponding on the surface • unusually clear or milky blue-green drain water flowing from or within the area (aluminium released by the acid sulfate soils acts as a flocculating agent.) • extensive iron stains on any drain or pond surfaces, or iron-stained water and ochre deposits **Landscape and other characteristics** • scalded or bare low lying areas • corrosion of concrete and/or steel structures.
potential acid sulfate soils	**Soil characteristics** • waterlogged soils-unripe muds (soft, buttery, blue grey or dark greenish grey) or estuarine silty sands or sands (mid to dark grey) or bottom sediments of estuaries or tidal lakes (dark grey to black) • presence of shell • soil pH usually neutral but may be acid-positive Peroxide Test **Water characteristics** • water pH usually neutral but may be acid

Source: Ahern et al *(1998a).*

7.3.3 Planning and management options

Management options vary according to the soil/sediment type and sulfide content (acid-forming potential), local hydrology and environmental sensitivity of the area. They may be broadly categorised under the headings, ‘New developments’, and ‘Existing acid-sulfate conditions’.

Land-use zoning and development control provisions in Local Environmental Plans (LEPs) are a key regulatory mechanism for ASS management. When proposing to undertake works which are likely to disturb acid sulfate soils or the associated watertable, a preliminary assessment should be undertaken and advice should be sought from the local council as to whether a development consent is required. Even if development consent is not required, an environmental assessment under Part 5 of the *Environmental Planning and Assessment (EP&A) Act 1979* may be required (Ahern et al 1998a).

Refer to the NSW ASS Manual for details of planning considerations. However, in most cases, or in any circumstances where no planning approval or consent is required, a good practice for superintendents overseeing works likely to disturb acid sulfate soils is to consult a person suitably qualified in ASS investigations (e.g. soil scientist) and conduct a preliminary assessment in accordance with the ASS Manual.

If the preliminary assessment confirms the presence of acid sulfate soils on the site, a sampling program should be designed to understand the extent and characteristics of the soils. If the soil sampling program establishes that a management plan is required to be prepared in accordance with the ASS Manual, additional soil surveying and sampling may be required to provide information to develop the management strategy. The level of investigation will depend on the characteristics of the site, particularly site variability, the type of disturbance proposed and the sensitivity of the surrounding environment (Ahern et al 1998a).

Where required, the selection of appropriate mitigation strategies will depend on the nature and scale of the works to be undertaken, the soil characteristics (e.g. concentration of sulfide, the variability of the material, the soil's physical characteristics and inherent neutralising capacity), the surface and sub-surface hydrology, the sensitivity of the surrounding environment and the past history of the site (Ahern et al 1998b).

The following outlines the most common mitigation approaches (Ahern et al 1998b):

- avoid disturbing acid sulfate soils by not undertaking works on land where they are located,
- if acid sulfate soils are present on the land, avoid disturbing them by not digging up the soil or lowering the watertable,
- if acid sulfate soils are to be disturbed, manage the acid generation potential, neutralise any acid produced, prevent any acid water leaving the site and use acid resistant construction materials,
- if acid sulfate soils have previously been disturbed, undertake works which will manage any acid already being produced, will minimise further production and will remediate any degradation in the long term,
- avoid using acid sulfate soils for land formation -if these soils are to be used, manage the acid generation potential before the material leaves the site where it originates,
- if material is very sandy, separate pyrite by sluicing,
- bury acid sulfate soils below the permanent water table.

7.3.4 New developments (course construction/redevelopment)

A. Avoidance is often the best option.

No acidic products will be released if ASS are left undisturbed and under the watertable. The cost of ASS remediation can be substantial and high-quality initial investigation can provide substantial savings by avoiding 'hotspots' at the design stage. Where possible, works should be designed or redesigned to minimise disturbance of ASS, avoid any 'hotspots' and consider alternatives for groundwater use and management.

B. Treat excavated acid sulfate material.

Where disturbance of material is necessary three main options exist for treatment of excavated ASS:

i. **Neutralisation**—Sufficient neutralising material (including a safety factor of 1.5) must be mixed thoroughly with exposed ASS to neutralise all existing and potential acidity likely to be produced from oxidation of sulfides. Finely ground agricultural lime (pH ~8.2) is usually the safest, most economical material currently available for soils. Other types of lime that may be used include quicklime, mixed lime and dolomite, which are all less efficient. Other promising materials under trial include 'red mud', a waste product of bauxite mining.

ii. **Rapid reburial**—Excavated material from below the watertable that has not been exposed to air can be transferred immediately back below the watertable in a pre-existing or constructed hole/water body (or 'borrow pit'). As long as the material has not acidified and is buried below the permanent watertable, no neutralisation will be necessary.

iii. **Separation of iron sulfides**—Sluicing or hydrocloning of coarser sediment types, e.g. sands, can be used to partially or totally remove acid-producing sulfides.

Monitoring of all excavated soils and runoff waters must be carried out during and after the construction/development process.

C. Create/recreate a 'freeboard' and drainage control.

During design and implementation of new developments, planning should allow for the creation (or recreation) of a non-sulfidic 'freeboard'. This provides a zone within which the watertable can be regulated to avoid activation of potential ASS beneath. Drainage design should be planned to minimise deep drainage by laser-levelled falls and broad, shallow dish drains to limit the exposure of potential ASS by avoiding drawdown of the watertable.

'Clever' weirs that allow flow rates to be regulated should be installed in main drainage canals to maintain the watertable fluctuations within the 'freeboard'.

7.3.5 Existing ASS conditions

The options for management of areas where ASS has already been disturbed are:

- remediation;
- mitigation at the source; or
- mitigation of the discharge.

i. Remediation

Remediation is generally not an option within existing landscaped areas because of golf course downtime and expense, but neutralisation of near-surface ASS in ‘rough’ areas adjoining the course can substantially reduce environmental impacts.

ii. Mitigation at source—drainage control

This involves drainage redesign to replace deep drainage with shallow, broad drains with laser-levelled falls, and ‘clever’ weirs to regulate the watertable above potential ASS material. If the existing ‘freeboard’ layer is less than 0.7–1.0 m thick, consideration should be given to creation of such a layer by a combination of tillage and liming.

iii. Mitigation of acid discharge

This involves the installation and maintenance of a permanent automatic water-monitoring and lime-dosing facility in exit waterways. Generally, water pH must be controlled to between 6.5 and 8.5 although special conditions may apply to some sensitive waters. As a minimum, water pH must be at least 6.5; iron and aluminium levels should be brought to below ANZECC and ARMCANZ guidelines.

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Further reading and ASSMAC contacts

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Acid Sulfate Soils and Their Management Coastal Queensland, Eds: K.M. Hey, C.R. Ahern, V.J. Eldershaw, J.M. Anorov and K.M. Watling, 1999, DNR, Indooroopilly DNRQ990058 *Acid sulfate soil priority management areas* (various regional reports in a series) NSW Department of Land and Water Conservation, Tulau, M. J (1999); Talau, M. J. and Naylor (1999); or Davies, M. and Mumby, B. (1999).

- ASS inquiries may be directed to the Acid Sulfate Soil Information Officer, Wollongbar Agricultural Institute, Bruxner Highway, Wollongbar, NSW, 2477.
- ASS risk and adapted planning maps are available from regional offices of the Department of Water and Energy; each coastal council in NSW will also have copies.
- Copies of the NSW ASS Manual can be purchased from The Information Centre, Planning NSW, Telephone: 02 9762 8000 (switch) or 02 9762 8044 (enquiries) or see the website www.planning.nsw.gov.au.

SECTION EIGHT

Native Vegetation and Wetlands

Contents

SECTION 8: Native Vegetation and Wetlands

KEY CONCEPTS

Management of the native landscape has several important benefits. It helps:

- maintain a diversity of plants and animals;
- protect ecosystems;
- *improve water quality;*
- minimise erosion;
- create lower-maintenance landscapes;
- provide habitats in urbanised areas; and
- reduce mowing, chemical applications and water use.

Wetlands provide several benefits on golf courses:

- they are a source of irrigation water;
- they cleanse stormwater;
- they filter nutrients; and
- they create wildlife habitats.

All native landscapes and wetlands need to be managed so that they maintain their integrity and function.

Golf course construction that incorporates native landscapes and wetlands provides these very important functions:

- environmental,
- aesthetic, and
- golf strategy.

As well as these benefits there are cost savings through reduced maintenance, less chemical usage and lower fertiliser requirements.

8.1 INTRODUCTION

Golf courses encompass a wide range of environmental conditions from pristine woodlands to degraded farmland and include a diverse range of plant and animal communities. Wetlands, including coastal wetlands, bogs, swamps, ponds, rivers and some open drains, are also an important part of this landscape. Golf courses in urban areas can often represent the area's remaining examples of the indigenous flora and fauna, or can form a link between fragmented areas of bushland. While the golf course has to operate as a golf course and not a nature reserve, it still has a duty of care to manage these areas in a responsible and sustainable manner. They can be one of the significant features and attractions of the golf course and help maximise the environmental benefits of the golf course.

8.2 NATIVE VEGETATION

Management of the native landscape has several important benefits. It helps:

- create a healthier mosaic of land uses;
- maintain a diversity of plants and animals;
- maintain the gene pool;
- protect ecosystems and ecological communities;
- provide habitat and corridor linkages;
- improve water quality;
- minimise erosion; and
- create lower-maintenance landscapes, reducing the dependence on water and chemicals.

The introduction of locally native vegetation into ‘no-play’ areas enhances the landscape and reduces the mowing efforts. However care should be taken to only undertake plantings in areas where natural regeneration is likely (e.g. no-mow zones) and to use species that occur in the local area. Reasons for introducing native vegetation include:

- providing food and shelter for animals, birds, and insects currently threatened by loss of habitat;
- reducing mowing, chemical applications and water use;
- providing an effective alternative to turfgrass, reducing maintenance costs and resources required;
- promoting the opportunity to enhance biodiversity;
- providing the opportunity for community education and awareness, both for members and neighbours; and
- keeping nature’s beauty close at hand.

Revegetating areas or allowing previously maintained areas to regenerate will provide excellent buffer zones and reduce maintenance costs. However, they should not result in deep roughs that inhibit play. It is also important not to place a regeneration area in the line of sight of a golf hole (Scenna and Morrison 1998) (see Figure 8.1). Appropriate placement areas may include behind tees and greens, beside cart paths, or bordering edges of a golf hole, including edges of forests, water courses and wetlands.

Creating buffer strips along the banks of rivers and streams serves the dual purpose of improving aesthetics and providing a functional component of ecosystem enhancement. In particular, they:

- filter runoff to reduce nutrient, sediment, pathogens and chemicals that may otherwise enter a water feature;
- provide a barrier between nutrient-rich grass clippings and the water feature;
- reduce labour required in hand trimming and hand mowing; and
- provide erosion control (i.e. trap sediment, reduce velocities of runoff and flood flows, and protect valuable soil by binding it with plant roots);
- provide shading of waterbodies with taller vegetation, which reduces favourable conditions for algal growth.

Golf courses need to try to link significant native vegetation establishments into the local scheme of parks and conservation areas. This provides green belts or wildlife corridors in the urban environment for the movement of native fauna and for maintenance of genetic diversity (AGU 1998).

CASE STUDY – NELSON BAY GOLF CLUB

The Nelson Bay Golf Club is a 27-hole golf course at Nelson Bay, Port Stephens, New South Wales surrounded by towering native trees set against the forested hills of the adjoining Tomaree National Park. The initial course was constructed about 40 years ago and is a coastal bushland course on sandy soils situated less than one kilometre from the Nelson Bay township. Whilst this location is an advantage for golfers to access the club, it creates many environmental challenges. During the past ten years the golf club has actively worked to improve and protect the golf course environment and its surrounds, by showing how a golf course can integrate the requirements of golf while preserving and improving the native flora and fauna.

An extensive native tree-planting program has been undertaken over the past 10 years with more than 5000 indigenous trees planted in the first stage, including *Eucalyptus robusta*, *Eucalyptus nicholii*, *Eucalyptus botryoides*, *Acacia spp.* and several *Callistemon* species. Areas between fairways have been left to regenerate wherever possible and a campaign to re-introduce native animals to the area has commenced. Wallabies, koalas and kangaroos have been released onto the course as part of the WIRES Program (a program for the rehabilitation of injured native animals).

In 1996, the Club decided to embark on the development of a further nine holes. One of its priorities was the retention of important indigenous vegetation. Pacific Coast Design (PCD) was engaged to develop the master plan to link the three proposed nines into the club zone and to ensure balance within the three nines. Prior to finalising the design and obtaining the appropriate planning permits, an environmental report was undertaken and used as the basis for a final routing of the new holes by PCD. Using a combination of aerial photography and ground survey to pinpoint nominated trees, the routing specifically protects habitat areas (selected trees) for Squirrel Glider and the Masked Owl. The wildlife survey report noted that the only koala population found during the report study was on the existing golf course. Native corridors, approximately 30 metres wide have been left between the fairways and around the perimeter of the new area.

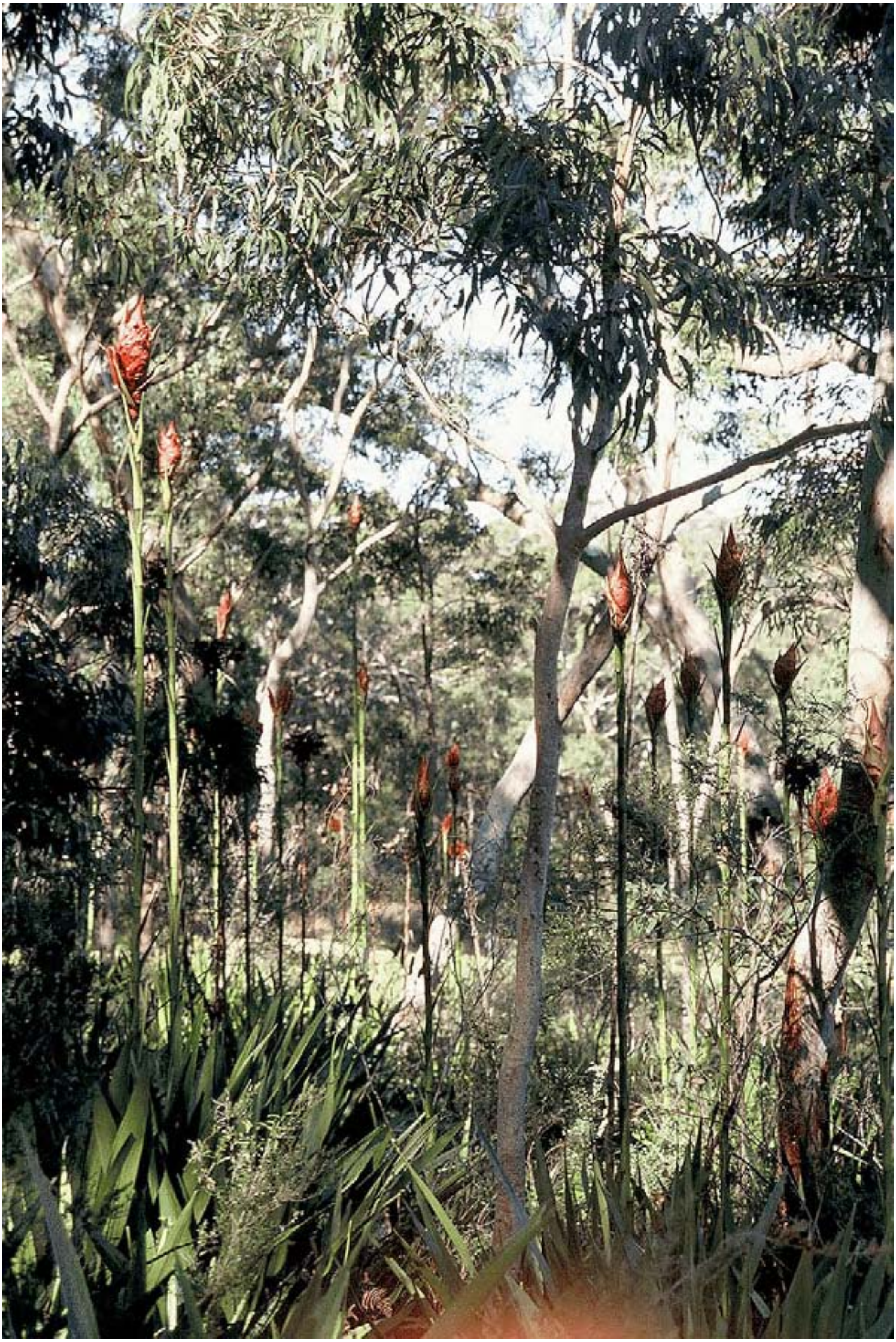
Incorporated in the new nine holes is an area consisting of two lakes where the fringes have been planted with native wetland plants to encourage bird life. An area of approximately two hectares, in the north-east corner, has been retained as a native reserve. Some 20,000 tubes of native grasses and approximately 2000 trees have also been planted as part of this project. A feature of the new nine is the spectacular Gymea Lily (*Doryanthes excelsa*), one of the most conspicuous of New South Wales native plants. It is found in open forest, on sandy soils with its most outstanding feature being the stem that can be up to 4 metres long with a compact head-like panicle of red flowers.

During clearing for the new nine, an environmental consultant was on site to ensure any native wildlife disturbed was either relocated to the adjoining national park or the existing golf course. The PCD designers visited the site during this phase to modify the routing of the new holes to further protect any significant sites found within the area.

Dead trees have been retained as nesting sites unless they are a potential danger. As part of the ongoing management of the course and surrounds a management plan was developed and includes water testing in conjunction with the Hunter Water Board and soil sampling on a regular basis. There is strict control on nitrogen and phosphorus applications and no fertilisers are applied near native bushland areas. Since 1993 there has been a 45% reduction in the use of nitrate and phosphate fertilisers.

Native Bushland — Nelson Bay Golf Club

Gymea Lily



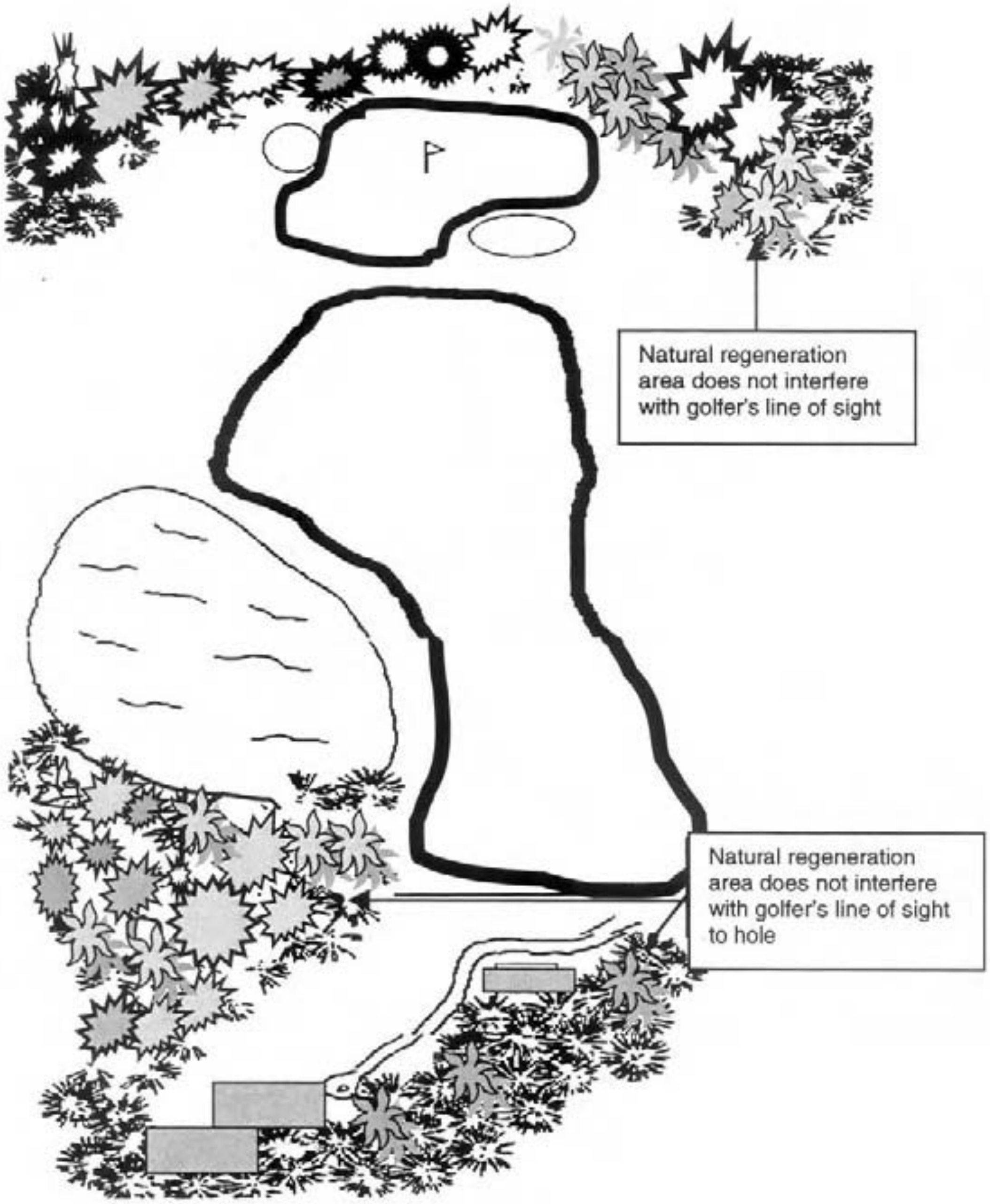
8.3 PONDS, LAKES AND WETLAND AREAS

8.3.1 Function

Wetlands include coastal wetlands, bogs, ponds, swamps, river margins and some open drains. Wetlands on golf courses:

- create a focal point in the landscape;
- are a source of irrigation water;
- cleanse stormwater by allowing settling of sediments, thereby protecting downstream water quality;
- filter nutrients, thereby protecting downstream water quality; and
- create or provide wildlife habitats.

Figure 8.1: Natural Regeneration Areas on a Typical Golf Hole



Adapted from Scenna and Morrison *1998*

Natural wetlands on and off-site should be protected in accordance with the goals and principles of the NSW Wetlands Management Policy (see NSW Government 1996). These principles include: discouraging the construction of purpose built wetlands on the site of viable natural ones; ensuring water entering wetlands should be of sufficient quality so as not to degrade the wetland; actively rehabilitating degraded wetlands and their habitats and processes as far as practical; conserving wetlands of regional or national significance (e.g. SEPP 14 wetlands).

For new golf course developments, there may be wetland protection provisions in LEPs or local wetland plans of management that should be taken in to consideration, in addition to the NSW wetlands policy.

The design and construction of ponds, lakes and wetlands is a specialist area and appropriate advice is always required. However, the first step in design is to specify the purpose and function of the wetland or water feature. Is the feature to be ornamental, a water storage for irrigation, a stormwater-control structure, a nutrient-stripping pond or wildlife habitat? Once these questions are answered, then the shape, size and profile of the water body can be determined, as well as the plant species to be used.

From an environmental management perspective, water conservation is probably the single most important reason for constructing a water body. However, another important reason for enhancing water bodies and improving their function is to improve water quality both for use on the golf course and to minimise the development of aquatic weeds that require costly control methods. While the construction and management of the water body is very important, it is also equally important to determine the influence of the watershed on that water body. The rate of sediment and nutrient input into a pond and into water bodies in general depends on the land uses within the watershed. Because of the link between ponds and watersheds, management of ponds must take into account the watershed. The construction of the pond itself can also influence water quality, particularly on acid sulfate soils or where there is a shallow, saline aquifer. Design must also ensure adequate environmental flows below the retention area.

CASE STUDY: LONG REEF GOLF CLUB

Long Reef Golf Club is situated on the northern beaches of Sydney, surrounded by the ocean on three sides. The area covers 55 hectares with an additional 60 hectare aquatic reserve. Over recent years the club has taken an interest in conservation and land management and many innovative projects have been undertaken. A number of areas in which Long Reef demonstrates best practice include:

- wetland rehabilitation
- wildlife management
- community education and involvement
- co-operative work with other government and non-government organisations

Wetland Rehabilitation

In 1995 Long Reef applied for a NSW Environmental Trust Grant (administered by the NSW Department of Environment and Climate Change) to assist in the construction of a series of wetlands on the course.

The purpose of these wetlands was:

- restoration and enlargement of the existing wetland area
- prevention of untreated stormwater flowing to nearby Fisherman’s Beach and the Aquatic Marin e Reserve
- recreation of a wetland ecosystem to treat urban runoff
- extension of the wildlife corridor by complementing Dee Why Wildlife Refuge
- utilisation of the enlarged area as a water harvesting resource.

Extensive areas of the golf course were regenerated as a series of wetlands. These wetlands have been designed for stormwater treatment, decreasing the flow and pollutant load of discharges to nearby Fisherman's Beach. The stormwater entering the first two wetlands carries significant nutrients, road grit and rubber. Water exiting the series of ponds is clear and wetland plant growth has been aggressive, with over 9000 wetland plants eg *Baumea articulata* and *Carex apressa* having been planted. The re-use of this stormwater for irrigation now sustains the majority of the needs of the golf course, in lieu of potable water previously supplied at the rate of one megalitre per day at peak periods.

Observations to date indicate that many species (e.g. native macrophytes, frogs, snakes, waterfowl and fish) have benefited from the wetland construction. Regular monitoring for water quality and fauna diversity and abundance is conducted by the golf club's environmental officer.

Wildlife Management

In 1997 approval was given by the NSW National Parks and Wildlife Service for the translocation of eggs, tadpoles and frogs of the endangered Green and Gold Bell Frog to the wetland habitat at Long Reef Golf Club. This was possible due to support from the Australian Museum, Taronga Zoo, the Natural Heritage Trust and Warringah Council.

In 1998, 1400 Green & Gold Bell Frog tadpoles (from a breeding program at Taronga Zoo) were released into 4 of the 7 wetland ponds, with two other wetland ponds being especially created for the frogs. In the first year, over 110 frogs were counted. A community group, the Long Reef Frog Conservation Group was set up to conduct monitoring of frog populations through regular surveys. They have approximately 80 members and are coordinated by a student at the University of NSW. Scientists, researchers and volunteers continue to monitor the frogs and tadpoles in and around the ponds on a regular basis.

Long Reef Golf Club has also been active in increasing the numbers and diversity of birds on the site. It constitutes a unique area of remnant coastal bushland, with banksia trees and other native trees and shrubs forming a fragmented chain of vegetation traditionally home to a variety of birds, some of which are migratory. Full-time 'residents' include the Australian wood duck, Pacific black duck, black swan, Australasian Grebe, dusky moore hen, purple swamp hen, masked lapwing, Richard's pipit, superb fairy wren, reed warble, red wattle bird, nankeen kestrel, noisy minor, brown thornbill and the bush stone curlew. Visiting birds include the white face heron, Eastern reef egret, black shouldered kite, white bellied sea eagle, yellow tailed black cockatoo, galah, sulphur crested cockatoo, corella, rainbow lorikeet, common koel and the kookaburra.

Black swans were once numerous around Dee Why Lagoon, but due to urbanisation they have all but left. In the spring of 2001, with a Section 120 licence from the NSW National Parks and Wildlife Service and assistance from Featherdale Wildlife Park, a pair of black swans were released into the wetlands. The birds have been pinioned and so are unable to fly, hence an island habitat in the wetlands was very important. The pair are monitored regularly and have settled into their new home well, grazing on the native aquatic vegetation. It is hoped they will start breeding in the following years.

Community Education and Support

Long Reef Golf Club has realised the importance of good communication and community involvement in the various aspects of the club's environmental management. As noted above, volunteers have been crucial in assisting with the Green & Gold Bell Frog program and have also been involved in bush care and regeneration. The successes of the programs have been communicated to the public through the local newspapers, community radio, school tours and the golf club's regular newsletters. The club has established strong links with the Australian Museum, Taronga Zoo, Warringah Council, universities and local schools.

8.3.2 Management of water quality

Managing the water quality of the water, such as wetlands within the golf course, is very important as it will have an impact on turf quality, performance of the water bodies and water quality downstream. Under the *Protection of the Environment Operations Act 1997* (POEO) it is an offence to pollute waters (Section 120). It is also an offence to cause or permit water pollution. 'Waters' means the whole or any part of:

- any river, stream, lake, lagoon, swamp, wetlands, unconfined surface water, natural or artificial watercourse, dam or tidal waters (including the sea) or
- any water stored in artificial works, any water in water mains, water pipes or water channels, or any underground or artesian water.

Therefore, it is an offence to pollute stormwater. Pollution includes substances mistakenly viewed as harmless because they are 'natural' such as leaves, grass or soil as well as chemical and other substances. The use of additives such as dyes or other chemicals in ponds needs to be minimised and managed to ensure there is no polluted run-off to receiving water bodies as this may constitute a breach of POEO.

A three-year study of the water quality on 44 golf courses in NSW demonstrated that the quality of the water flowing through the golf course was improved (Kaapro 1999). Detailed research sponsored by the United States Golf Association (USGA1995) has demonstrated that:

- turfgrass is a very effective filter for nutrients and pesticides and far more effective than cropland;
- most fertilisers and pesticides showed little potential to affect groundwater and surface water quality. Turfgrass managers can take a few simple steps to further reduce the chance of groundwater or surface water contamination;

- more research is needed to investigate a wide range of soil/pesticide interactions; and
- each product on the golf course must be carefully evaluated.

Eutrophication of water bodies on golf courses is a constant management consideration. It is linked to high nutrient levels and increased suspended sediment in the water due to wind turbulence, stormwater or death of bottom-rooted plants. Eutrophication can be reduced by:

- keeping water temperatures lowered by having some deepwater areas and covering up to half the water with emergent or floating plants. Very often the worst-affected ponds are shallow, are close to maintained turf areas, are small in area and have very little circulation;
- including a well-vegetated buffer and/or filtering vegetation around the water body. Grass buffers in particular act as very efficient filters;
- periodically removing rotting vegetation;
- not using fertilisers within 15 metres of the water body (Connolly 1990); and
- on golf courses that use recycled wastewater for irrigation not allowing sprinklers to spray into ponds and ornamental lakes.

While a range of factors contribute to favourable conditions for nuisance algae and aquatic plant growth, it is important to note that the levels of nitrogen and phosphorus required to cause algal blooms are very low. The risk of nuisance aquatic algae/plant growth is increased when ambient nutrient levels in the waterbody exceed the 'trigger values' given below.

Table 8.1: Default ANZECC & ARMCANZ (2000) 'trigger values' for nutrient stressors for slightly disturbed aquatic ecosystems in NSW.

Ecosystem type	TP (mg P L^{-1})	FRP (mg P L^{-1})	TN (mg N L^{-1})	NO_x (mg N L^{-1})	NH_4^+ (mg N L^{-1})
Upland river	20	15	250	15	13
Lowland river[a]	50	20	500	40[o]	20
Freshwater lakes & Reservoirs	10	5	350	10	10
Wetlands	no data	no data	no data	no data	no data
Estuaries[p]	30	5	300	15	15
Marine	25	10	120	25	20

a = values are 3 μgL^{-1} for Chl a, *25 μgL^{-1} for TP and 350 μgL^{-1} for TN for NSW east flowing coastal rivers. TP = total phosphorus, FRP = filterable reactive phosphate, TN = total nitrogen, NO_x = oxides of nitrogen; NH_4^+ = ammonium; DO = dissolved oxygen*

It only takes a careless application of fertiliser or relatively small amounts of contaminated stormwater runoff from urban areas to add sufficient nutrients to cause an algal bloom. Where water is taken from urban catchments, the first wave of drainage water should be diverted away from the main irrigation dam. This initial nutrient-enriched 'slug' of water can be diverted through a wetland filter before entering the main water bodies.

8.3.3 Water quality monitoring

Golf courses are part of much larger catchment areas that can have a significant influence on the water quality coming into the golf course. All golf courses should have a water testing program to monitor water quality and be able to initiate early remedial action if a problem appears to be developing. This is not only a sound environmental practice, but also an important agronomic practice. Regular checking of water quality for salinity and pH will ensure that turf damage does not occur inadvertently. The monitoring of nutrients (particularly nitrogen and phosphorus) provides valuable information on the quality of:

- the incoming water supply;
- the function of wetland systems;
- the condition of ponds and lakes; and
- water leaving the golf course.

STRATEGIC SAMPLING POINTS

Strategic sampling points should be identified on the golf course, for example:

- where a river, stream, or stormwater pipe enters the golf course;
- each pond or lake; and
- exit point from the golf course.

The Department of Planning, local councils and other groups monitor water quality in many rivers and waterways and there are numerous reports available. The NSW Department of Environment and Climate Change has recently released its *State of the Environment 2000* report which has a comprehensive review of the condition and future management of New South Wales water resources and catchment areas (refer to: www.epa.nsw.gov.au/soe/soe2000/cw/). It is important that golf clubs have some general knowledge of their catchment area, particularly as it relates to water quality. Some knowledge of the wider catchment area provides golf courses with valuable information on potential sources of pollutants that may affect the golf course and conversely down stream areas that may be impacted by golf course activities. It is very useful to establish a good relationship with your local council, especially the environment staff. They can help with local catchment knowledge, as well as knowledge of local flora and fauna, construction issues etc.

WATER TESTING

Regular water testing should include the following parameters:

- pH and electrical conductivity (EC);
- phosphorus, nitrate, nitrite, TKN;
- sodium, chloride, calcium, magnesium and bicarbonate/carbonate for irrigation waters; and
- heavy metals where there may be a source of such contaminants.

The frequency of testing should be 2–4 times a year.

8.3.4 Plant selection for ponds/lakes/wetlands

When designing wetland areas and water bodies it is necessary to consider the plant species available or suitable for your particular area (Dowling and Stephens 1995). Using plants that occur naturally in the area is always preferred. Again, talk with your local council. Plant selection requires specialist advice, however, *Waterplants in Australia – A Field Guide* (Sainty and Jacobs, 1994) is an excellent reference. Another useful reference is the newly formed national program, *Flora for Fauna.* See the Nursery and Garden Industry Australia website, www.ngia.com.au for further information. This program will help you source plants indigenous to your local area.

Water bodies on golf courses can often be neglected or disregarded unless a specific problem occurs and the following checklist is provided as a prompt to check the function, purpose and maintenance inputs of these water bodies.

Table 8.2: Checklist — water body management

Item	Comment
1. Size of water body • Area (ha) • Volume • Average depth	
2. Purpose/function • Irrigation • Ornamental • Nutrient stripping • Stormwater control • Other	
3. Sources of water • On course (%) • Off course (%)	
4. Proximity to high-maintenance turf areas (metres)	
5. Vegetation • In water body • In riparian zone	
6. Is water body interconnected with other water bodies?	Yes No
7. Is water tested regularly? • parameters tested	Yes No
8. Average water quality	
9. Watershed/catchment **Outside the golf course** • Grazing • Horticulture • Shopping • Urban • Industrial **Inside the golf course** • Carpark/hard areas • Turf areas • Drainage • Watertable	

10. Sources of water • Bore • Rainfall • Wastewater • Runoff (on course) • Stormwater (off course)	
11. Water body management issues • Algal blooms • Excessive aquatic growth • Poor water quality (e.g. salinity) • High nutrients • Sedimentation	
12. Maintenance **Maintaining edge of ponds** • Equipment • Labour • Frequency • Weed control • Chemicals **Removal /control of water plants** • Labour • Equipment • Frequency • Emptying/cleaning ponds	

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SECTION NINE

Clubhouse and Facility Management

Contents

SECTION 9: Clubhouse and Facility Management

KEY CONCEPTS

- Clubhouse operations can be a major cost in golf course operations.
- Choosing more efficient products and properly maintaining current equipment can reduce operating costs.
- Waste avoidance and minimisation and re-using and recycling resources where ever possible can significantly reduce costs.

9.1 INTRODUCTION

The principal environmental concerns in golf course management centre on water, pesticide and fertiliser use and the potential for water pollution. These issues centre on turf management and are the responsibility of the superintendents and green keeping staff.

There are also significant environmental and economic benefits to be achieved in sound management of the clubhouse and facilities. The clubhouse and associated members' facilities use water and energy and produce wastes in the process. The design and positioning of these facilities can have a significant impact on energy use through cooling and lighting.

The clubhouse produces wastes, including:

- organic (e.g. food scraps etc.);
- recyclables (glass, paper, recyclable plastics and metal);
- residual waste (non-recyclable plastics); and
- cooking oils/fats.

9.2 WATER EFFICIENT CLUBHOUSES

Water use in clubhouses can be significantly improved through the installation of water efficient appliances. This makes both economic and environmental sense. Appliances such as AAA rated shower heads and water efficient taps and dual flush toilets will reduce water consumption by as much as 20 per cent. Many councils are now encouraging the installation of rainwater tanks in addition to the appliances already mentioned. Consult your water authority and/or council for advice and assistance.

9.3 ENERGY EFFICIENT CLUBHOUSES

The Department of Environment and Climate Change NSW has produced a document specifically for clubs to assist them in improving their energy efficiency. The document, *Club of the Future*, is a practical model to assist clubs in adopting energy efficiency features while improving profitability and reliability. The following information has been adapted from the *Club of the Future* document.

Good energy management offers clubs mid-and long-term returns. The club will benefit by: being more reliable because of better quality plant that requires less maintenance and by being considered more environmentally responsible within the community because when you reduce the amount of energy used there is an automatic reduction in the level of harmful greenhouse gas emissions. Energy efficiency can be achieved through investing in some of the following key energy efficiency features.

Building Management System (BMS)

A computerised control system for managing all the operating systems in the club gives tighter control and the ability to switch systems on and off when required. This means big cost savings.

- a BMS should at least cover air conditioning, domestic hot water and lighting;
- large, good quality video monitors give operators tighter control;
- robust, reliable sensors allow operating systems to be switched on and off as required;
- Computer-based lighting and air handler software allows non-engineers to access the BMS.

Air conditioning

The air conditioning system determines the quality of the internal environment of the club and is the major energy consumer.

- outside air economy cycle allows for free cooling in winter and spring;
- 3-stage centrifugal chillers are twice as energy efficient, and cost effective, as packaged air conditioning;
- a gas-driven chiller reclaims heat for the swimming pool or domestic hot water needs;
- high-efficiency pumps and motors cost little or no more than less efficient motors;
- variable speed drives on selected motors cut energy consumption by 50% with only 12.5% reduction in flow of water or air;
- an air-to-air heat exchanger cools hot air coming into the building with outgoing cool air instead of throwing it away;
- electronic expansion valves improve the flow of refrigerant in chiller compressors.

Metering and sub-metering

By installing meters on each energy source it is possible to identify areas that are using excess energy.

- smart meters allow the accuracy of the main account meter to be checked;
- put meters on each mechanical and electrical switchboard to know where the energy is being used;
- power factor correction makes the energy supply system more efficient.

Lighting

Lighting contributes to the ambience and excitement of the club but can be an unnecessary expense. Try new energy efficient lighting.

- new T-5 fluorescent tubes, tri-phosphor fluorescents, metal halide and fibre optics can all reduce the annual lighting bill while providing the right light output;
- with retrofitted silver lux reflectors you only need half as many light tubes for the same lighting level;
- do not use low voltage downlights except where needed for aesthetic reasons, use electronic ballasts and 35w globes, which provide the same light as a 50w;
- control and dimming of lighting is essential to minimise energy use;
- occupancy sensors save money by cutting power use when it's not needed.

Car park ventilation

When car park ventilation runs 24 hours a day, it can represent up to 20% of the operating costs.

- use natural ventilation if possible;
- by monitoring carbon monoxide levels you can shut down the ventilation system at times of low car park use;
- ensure the BMS switches off the ventilation system after hours.

Swimming pool heating

Swimming pools, particularly open air pools, use large amounts of energy. Supplying the energy from other operating systems can reduce costs.

- reclaim heat for the pool from air conditioning chillers;
- reverse cycle air conditioning units de-humidify the environment in closed pools and inject heat into the pool water;
- solar hot water system provides free energy for pool heating all year round;
- look at cogeneration as a way to make both hot water and electricity cost-effective.

Commercial refrigeration

All clubs need commercial refrigeration. The way the system is operated will affect the operating costs.

- Air cooled condensers need good air flow and should be located on the roof;
- ensure BMS switches off refrigeration in beer and wine rooms when not in use in the early morning hours;
- electronic expansion valves improve the flow of refrigerant in compressors.

Commercial kitchen equipment

Look for 5-star energy efficient kitchen equipment, now available from manufacturers, to save you money.

- modern refrigerated display units have triple glazed fronts and highly insulated walls for reduced power use;
- gas-fired dishwashers, which use much less energy than electric, are now on the market;
- a Maxomicer cuts energy used for making ice by 30% by using water draining out of the icemaker to cool incoming water.

Domestic hot water

The significant amounts of energy and water used to provide domestic hot water for showers, amenities and washing up can be reduced.

- a gas-driven chiller reclaims heat for the domestic hot water needs;
- solar cells with gas boost or solar heat pump hot water units cut energy costs;
- reclaim heat energy lost down the shower drain with a 'GFX' drain reclaim unit.

Passive solar design

Where clubs are being renovated or designed from scratch, simple architectural features which minimise air conditioning and lighting needs can be built in.

- vertical louvres on east and west sides of building;
- planting provides shade around exposed walls and glazed surfaces;
- awnings and shading protect large glazed areas from direct sunlight;
- locating premises appropriately ie with NE focus.

Building integrated photovoltaics

Photovoltaic cells located on the outside of the building provide a source of power which is fed into the grid and credited to the club.

More information can be obtained at www.environment.nsw.gov.au

9.4 FOOD SENSE

The waste generated within the clubhouse can be significant and needs to be attended to as part of the overall environmental improvement program for a golf course. The Department of Environment and Climate Change NSW has addressed the issue of waste generated in the clubhouse and in particular food waste and have produced a very good guide for clubs called *Food Sense – a guide to reducing waste in the hospitality industry* (1998). The following information is taken directly from the booklet and from other NSW DECC publications. These can be purchased from the NSW DECC (Ph: 131 555) or viewed on the website: www.environment.nsw.gov.au

In NSW, green waste (garden, food and wood waste) represents approximately 30% of the total waste material generated. About 150,000 tonnes of food waste from businesses and industry is buried in landfill each year in NSW. In landfill this potentially valuable resource is wasted. The organic matter cannot be put to any productive use once it is mixed with different types of waste and buried. Food waste- along with garden waste and other organic materials -creates some of the biggest environmental problems associated with landfills. It's the food in waste that attracts birds and rats, which means that valuable landfill space is used up by covering the waste each day with a thick layer of soil. As the organic wastes compress and break down under this cover, gases and liquid are formed:

- **Landfill gas** — which consists mainly of two gases (carbon dioxide and methane). This has a strong smell and contributes to the Greenhouse effect.
- **Leachate** — which is the liquid that forms in landfills when water passes through it. The water picks up dissolved organics that can cause havoc in our waterways if not properly collected and disposed of.

Because of these problems, special landfills are needed. These cost more to manage, as they must meet higher environmental standards.

Take the first step towards reducing your waste

Once your organisation is committed to reducing kitchen waste, it is good to establish a baseline from which you can set goals and evaluate your improvements. You can do this by undertaking an environmental review of your current operations. (Ideally, a review or audit of your kitchen operations should be part of a review of all parts of your business.) Here are seven simple steps to get you started.

Step 1. The paper audit: Check how often your waste is picked up and how full the bins are. Check purchasing records to work out whether poor stock rotation or spoilage is leading to wastage. Work out how much waste disposal costs your business.

Step 2. The walk-through: Check what's in the garbage every day for one week. Note the types and amounts of wastes thrown out. (Note: You need to wear protective clothing (including gloves and masks) while checking through garbage, and to follow occupational health and safety requirements for this work at all times).

Step 3. Talk with staff: Discuss options with staff for reducing waste. Ask staff for their ideas.

Step 4. Prioritise the waste streams: Identify waste by checking items against the '3 Rs'. First, ask what waste you can (in order of preference): - Reduce - Reuse - Recycle.

Step 5. Develop a plan: Set some goals – (e.g. to reduce your waste by half in one year). Work out which wastes to target to reach this goal.

Step 6. Talk to staff, waste contractors and suppliers: Discuss your plan with staff, contractors and suppliers. Ask them to help achieve the waste reduction goal.

Step 7. Let your customers know: Promote your environmental aims to your customers and the local community. Now you are ready to make changes. A comprehensive review of operations may include looking at ways of reducing energy, water, chemicals and wastewater.

Apply the 3 Rs — Reduce, Reuse, Recycle

Often when we think about reducing waste, the first thing that comes to mind is recycling. While this helps recover resources, it is far more useful to avoid creating waste in the first place.

Reduce: Reducing waste means that the production of waste is avoided. Examples relevant to the food and catering industry include: reducing portion sizes if most customers are not eating all of their meal; buying less, more often- to avoid spoilage and reduce refrigeration needs.

Reuse: Reusing products means using something more than once. For example, you can: encourage staff to use coffee mugs rather than disposable (especially polystyrene) cups; reuse plastic condiment buckets or drums; replace disposable cutlery and plates with washable, reusable items.

Recycle: Recycling waste involves collecting certain products, which are then processed to make a similar product. Examples of recyclable products are cardboard boxes, glass bottles and jars, PET plastic bottles and aluminium and steel cans. By composting food waste, food scraps are recycled to form a valuable resource.

Reduce your waste and save money

The less rubbish you throw out the smaller your waste bill. By recycling as much as possible, preventing waste being created as far as possible, and finding ways of dealing with your surplus food waste, your business should be able to reduce its waste by at least half. Some businesses have reduced their waste by up to 90%! That represents more money for their business and a better environment.

Here are some suggestions

Purchasing: Avoid buying disposable items such as plastic containers and cutlery, paper towels and napkins. Use reusable table linen, crockery and cutlery. Ask suppliers to take back and reuse transport packaging such as crates, waxed cardboard and foam boxes. Avoid buying single-serve portions such as tomato sauce, jam, butter, sugar, salt and pepper. Buy in bulk and refill where you can into Health Department-approved dispensers. If storage space allows, buy shelf-stable products in bulk to reduce packaging and unit price. For example, buy bulk bar mixes in concentrate form and then dispense. Buy your coffee by the whole bean and grind it on site. Buy cleaning supplies -such as washing- up detergent — in concentrate. Use multi-purpose cleaners rather than job- specific ones. Look at the amount of food spoilage. If food is spoiling before it is used, you may need to buy less of it more often.

Support recycling by buying paper products made from recycled paper. Available items include toilet paper, paper towels, brown paper bags, chip buckets, take-away containers and paper for menus. Choose suppliers that provide recyclable packaging and packaging that has recycled content.

Product handling and storage: Check deliveries for rotten or damaged products and return any substandard goods. Rotate perishable stock at every delivery to reduce spoilage. Arrange with a local welfare organisation to take leftover prepared food.

Food preparation and storage: Adjust inventory levels on perishables to minimise waste due to spoilage or dehydration. If you are constantly throwing out dairy products or vegetables, you may be stocking too much inventory or not rotating it properly. You may need to adjust either the quantity or frequency of your orders. When preparing food, only trim off what is not needed. Over-trimming typically occurs during preparation of bulk meats and whole vegetables. If your waste audit reveals excessive waste from over-trimming, you may need to retrain your preparation staff or buy these foods already proportioned. Store raw vegetables in reusable airtight containers to prevent dehydration and spoilage.

Behind the scenes: Keep equipment well maintained to avoid unnecessary spoilage through breakdown. Clean fryers and filter the cooking oil regularly. Store used cooking oil and arrange to have it picked up by a cooking-oil recycler. This is generally a free service: the recyclers will supply you with a drum and arrange regular collection. Place rubber mats around dishwashing stations to reduce breakage of glass and china.

Front of house: Throwing out prepared food is a real waste of invested dollars, staff time and resources.

- Adjust meal sizes if meals are routinely returned unfinished.
- Offer half portions and children's meals.
- Encourage 'doggy bags'.

Worming down your Waste

Composting or worm farming to reduce your food waste can really make a difference. It reduces disposal costs and preserves a valuable resource.

Composting

Composting converts organic matter- such as food, grass, leaves, soiled newspaper and the like -into a sweet-smelling earthlike substance. Compost can be used as an alternative to artificial fertilisers: it improves the quality of soil by increasing its ability to hold water and nutrients. It's easy to make compost. Basically, it involves layering nitrogen-poor materials (described as poor or brown, these include dry leaves, straw, paper and sawdust) with nitrogen-rich materials (described as rich or green, these include fruit and vegetable scraps, weeds and animal manure). With the right mix of ingredients, plus water and air, rich soil-like compost can be produced in about 8-10 weeks.

Worm Farming

Feeding a worm farm with your food waste is also an option. Worms are voracious feeders, eating up to half their own body weight of fruit and vegetable scraps, juicer pulp, shredded paper, soaked cardboard and eggshells in one day. They turn your food scraps into worm castings, a rich fertiliser-like material that can be used straight on the garden. When making the decision to compost or worm farm, you might want to consider the following factors:

Space: How much space is available for the compost or worm farm system? Worm beds generally need less space than composting systems. How close are the nearest houses or businesses? Buffers of 250-500 metres are recommended for composting, as odours can be released when compost is turned.

Materials: What types of organic wastes are produced, and are storage facilities available? If only food wastes and some paper or cardboard wastes are produced, a worm bed is ideal. Composting requires the addition of a bulking agent to food wastes. Garden wastes such as leaves, grass and chipped tree branches make excellent bulking agents, but wetted cardboard, newspaper, paper towel or sawdust can also be used. Access to storage space for compost additives should be taken into account.

Cost/benefit: The following costs need to be considered:

- equipment costs
- labour costs
- material costs
- operating/maintenance costs

and weighed against the benefits:

- lower disposal costs
- reduced environmental impact and higher social benefits
- lower mulch, soil and fertiliser needs
- reduced need for pesticides and herbicides

9.5 CASE STUDIES

Two preliminary eco-efficiency studies have been undertaken on Queensland golf courses to determine the potential for improved resource management. The golf courses studied were Horton Park Golf Course and Gainsborough Greens.

The findings from these studies indicate some fundamental but important efficiencies that can be made in clubhouse operations. These improvements include:

- the replacement of incandescent lights with compact fluorescent lamps;
- the replacement of 42 lights has the following cost benefits:

Cost	$630
Annual saving	$134
Payback	4.6 years

- replacement of seals on refrigeration and freezer units;
- better control of air conditioning systems so that those in empty rooms can be switched off and come on only when a person enters the room (i.e. using sensors);
- keeping external doors closed with good sealing to prevent the entry of warm and humid air. Potential cost savings = $1000/annum;
- improved maintenance of air conditioning units (e.g. cleaning filters);
- reduction of heat loading to the building as a consequence of north-facing windows by using shade sails or reflective film on windows:

Cost of reflective film	$6,500
Energy savings	$4,500
Payback	1.5 years

- use of dual-flush toilets for water conservation (33% saving);
- improved waste recycling;
- collection of rainwater for use in the buggy facility to reduce equipment corrosion:

Cost of tanks etc.	$13,000
Savings	$3,800
Payback	3 years

- use of water-efficient shower roses (33% saving).

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SECTION TEN

Machinery Operations

Contents

SECTION 10:
Machinery Operations

KEY CONCEPTS

- Mowing is one of the highest maintenance costs in golf course operations.
- Mowing can produce significant noise pollution with neighbouring properties and requires new strategies in mowing practices.
- Maintenance of machinery should focus on ensuring optimal performance as well as minimising pollution
- There are alternatives to mowing including:
  - Use of growth retardants
  - Revegetation of play areas

10.1 INTRODUCTION

The operation of golf course facilities depends on the use of specialised machinery and in particular mowers, to produce surfaces that are suitable for the game of golf. Mowing is the most frequently undertaken operation and the use of mowers raises issues of noise and air pollution and energy use.

Some form of mowing is undertaken every day, providing that conditions permit the operation of mowers (e.g. wet weather can stop mowing operations). As a consequence, mowing and the associated labour costs can make up a significant proportion of the annual maintenance budget.

10.2 MOWING

Mowing regularly with the correct equipment that is well maintained is one of the key components in providing high quality turf surfaces. Turf areas that are infrequently mown or cut with poorly maintained equipment present unsightly, scalped and non-uniform surfaces that inhibit the game from being played at its best.

10.2.1 Costs associated with mowing

Minter Research (undated) was commissioned by Ciba Australia to determine the costs associated with mowing golf course fairways and roughs. The research was undertaken using a telephone survey of 25 golf courses in each of Queensland, NSW and Victoria. This survey was undertaken due to a lack of definitive costings on mowing and how mowing costs compare to the use of a growth retardant.

The cost of mowing was determined by examining all the inputs including:

- type and size of golf course
- frequency of mowing
- man hours taken to mow
- average wage rates
- cost of clippings disposal

- number and model of fairway and rough mowers
- replacement cost of mowers
- life expectancy of mowers
- total maintenance costs for mowers
- fuel costs
- insurance costs
- management measures to mitigate for noise

There is a wide range of variables that affect the cost, including wages, mowing time and equipment. There are also different costs according to the climate in different areas. The variables identified that have most impact are:

- mowing frequencies
- seasons, (i.e. the length of each growing (mowing) season in each area)
- man hours to mow, (i.e. the time taken by staff to mow one hectare of fairway or rough)
- the other main costs were maintenance and depreciation.

Fairway mowing was considered to be a lower cost operation compared to mowing roughs because it is relatively simple due to the lack of obstacles. On the other hand, rough mowing requires more maneuvering due to trees and other non-cut areas.

Two mowing seasons were identified with the peak mowing season being summer, with secondary being spring and autumn. There was little difference in regard to the variety of turf being mowed.

The mowing costs for New South Wales are detailed as follows:

Monthly mowing frequency — fairways

Peak	12/month
Secondary autumn	6/month
Secondary spring	6/month

Monthly mowing frequency — rough

Peak	6/month
Secondary autumn	3/month
Secondary spring	3/month

Hours required to mow fairways and roughs

	Fairways	**Roughs**
Peak	0.64 hrs/ha	2.22 hrs/ha
Secondary	0.64 hrs/ha	1.78 hrs/ha

Table 10.1: Cost per hectare per month — Peak

	Fairways	Roughs
Direct Costs		
Wages Labour Burden Clippings Disposal Maintenance	\$83.25 \$24.98 \$0.00 \$43.94	\$208.13 \$62.44 \$0.00 \$43.94
Sub Total	**\$152.17**	**\$314.51**
Equipment		
Depreciation Insurance	\$28.44 \$0.57	\$28.44 \$0.57
Sub Total	**\$29.01**	**\$29.01**
TOTAL	**\$181.18**	**\$343.52**

Table 10.2: Cost per hectare per month — Secondary

	Fairways	Roughs
Direct Costs		
Wages Labour Burden Clippings Disposal Maintenance	\$41.63 \$12.49 \$0.00 \$43.94	\$104.06 \$31.22 \$0.00 \$43.94
Sub Total	**\$98.06**	**\$179.23**
Equipment		
Depreciation Insurance	\$28.44 \$0.57	\$28.44 \$0.57
Sub Total	**\$29.01**	**\$29.01**
TOTAL	**\$127.07**	**\$208.24**

Table 10.3: Cost per cut per hectare — Peak

	Fairways	Roughs
Direct Costs		
Wages Labour Burden Clippings Disposal Maintenance	\$6.94 \$2.08 \$0.00 \$3.66	\$17.34 \$5.20 \$0.00 \$3.66
Sub Total	**\$12.68**	**\$26.21**
Equipment		
Depreciation Insurance	\$2.37 \$0.05	\$2.37 \$0.05
Sub Total	**\$2.42**	**\$2.42**
TOTAL	**\$15.10**	**\$28.63**

Table 10.4: Cost per cut per hectare — Secondary

	Fairways	Roughs
Direct Costs		
Wages Labour Burden Clippings Disposal Maintenance	$6.94 $2.08 $0.00 $7.32	$17.34 $5.20 $0.00 $7.32
Sub Total	**$16.34**	**$29.87**
Equipment		
Depreciation Insurance	$4.74 $0.09	$4.74 $0.09
Sub Total	**$4.84**	**$4.84**
TOTAL	**$21.18**	**$34.71**

10.2.2 Cost effective alternatives to mowing

Mowing is a critical and large part of golf course operations and is an area that offers good opportunities to increase eco-efficiency. Decreasing the amount of mowing will provide clear environmental (as well as economic) benefits. These include a reduction in the use of resources (eg fuel), decreased maintenance and upkeep requirements, a decrease in the number of times machinery needs cleaning, a decrease in the amount of green waste generated etc. The following are some practical steps to reduce mowing.

10.2.2.1 Rough maintenance

The most obvious opportunity is to reduce the area that is mown. This is going to be restricted to the roughs, which represent a higher cost per mowing per hectare than fairways. Roughs are often a controversial area on the golf course because roughs that are poorly maintained or have grass which is too long, result in slow play, lost balls and frustrated golfers. It is therefore important for each golf course that a policy on roughs is established and for each golf hole, ‘no-mow’ areas are identified. On golf holes that have large areas of grassed, open space that is out of play, considerations should be given to re-vegetating with native plants that do not require mowing. Native Australian vegetation will provide additional benefits such as attracting or increasing native birds and other native fauna.

In a US study (Sims, 1998), the costs of maintaining roughs were analysed for the Selma G.C in Alabama. The issues in this case were:

- appearance (needed to be manicured)
- clippings
- pine cones and leaf litter
- weed control

The golf course has a budget of about $500,000 with six full time personnel plus casuals. The grass type is predominantly Tifton 419 and common couchgrass. The labour and costs were calculated for the existing operations, including;

- mowing – 1,280 worker hours
- sweeping and blowing pine straw and leaves – 1,344 worker hours
- removing pinecones and debris – 624 working hours.

Pinecones, limbs, leaves etc. have to be disposed of without burning due to environmental restrictions.

In this situation the solution was to purchase a mulching mower (where traditionally a cylinder mower was used). The mulching mower mulched up leaves, pinecones and pine straw, there was reduced equipment maintenance, the process was quicker and the appearance improved. The cost comparisons are in Table 4.5.

Table 10.5: Cost comparisons of conventional rough maintenance compared to mulching

Practice	Time & expense of conventional methods	Time & expense of mulching	Savings with mulching	% Saving
Mowing roughs	1280 * $12, 288	1280 $12, 288		
Sweeping & blowing leaves & pinecones	1344 ** $12,902	672 $6, 451	672 $6, 451	50%
Pine cones & debris	624 *** $5, 990		624 $5, 990	100%
TOTAL	**3, 248 $31,180**	**1952 $18, 739**	**1296 $12, 441**	**40%**

* *Mowing hours did not decrease, however, width of mulching unit allowed 2 mowings/week*
** *Able to eliminate the equivalent of 2 workers, 3 days a week for 28 weeks*
*** *Able to eliminate the equivalent of 3 workers, 4 hours a day, one day a week for 52 weeks*

While the cost comparisons may not be directly comparable to New South Wales conditions, they do provide a good example of the process of determining current operating costs and how to compare alternative methods.

10.2.2.2 Growth regulators on fairways

Plant growth regulators (PGR) have been in use for many years, however, there has not been a wide adoption of their use because of:

- visual aesthetics (turf yellowing)
- growth suppression varies between plant species
- lack of turf recovery in high wear areas
- cost
  (Ohlson,1996)

There has been considerable research undertaken on determining the advantages of using PGRs and in particular the reduction in mowing and the associated costs. Johnson (1994) treated Tifway couchgrass with trinexapac- ethyl and found that vegetative growth was suppressed for 12 weeks and the number of mowings reduced by up to 70%.

Although chemical mowing is unlikely to replace mechanical mowing PGRs can reduce the mowing frequency. Johnson (1992) indicates a reduction in the number of required mowings and the associated labour, fuel and maintenance costs.

The market research undertaken by Minter Research compared the cost of using a PGR, trinexapac-ethyl (Primo®), with the costs of conventional mowing. Their research found that Primo® could reduce the growth rate of the turf by 50% for between 4 and 6 weeks. They have then assumed a maximum reduction in mowing of 50 percent.

COMPARISON OF COSTS OF MOWING WITH THE USE OF PRIMO®

Fairways

- Monthly cost of mowing is $181.18/ha in peak season
- Cost of Primo® based on $189.00/litre (5L container)
- Application rate and costs
  - Kikuyu (800ml/ha): $151.20/ha
  - Common couch (400ml/ha): $75.60/ha
  - Hybrid Couch (300ml/ha): $56.70/ha
- Cost savings based on reducing mowing by 50%
  - 4 weeks growth reduction: $84.97/ha
  - 6 weeks growth reduction: $127.46/ha

Roughs

- Monthly cost of mowing is $343.52/ha
- Application rate and costs
  - Kikuyu (800ml/ha): $151.20/ha
  - Common Couch (500ml/ha): $94.50/ha
  - Hybrid Couch (500ml/ha): $94.50/ha
- Cost savings based on reducing mowing by 50%
  - 4 weeks growth reduction: $97.70/ha
  - 6 weeks growth reduction: $146.55/ha

10.2.2.3 No-mow areas

All golf courses have areas that are unlikely to come into play but still require maintenance in order to maintain the visual aesthetics. Depending on the style of the golf course and the vegetation/landscaping plan, there is usually scope to change the vegetation type in ‘non-play’ areas to a less maintenance intensive species. For example planting out areas to native grasses that may require slashing 1 to 2 times a year or to other native shrubs and trees.

CASE STUDY

At Gainsborough Greens the managed areas have been reduced by 15% through revegetation of grass areas.

The costs involved were:

- Purchase of a tree spade to move trees from heavily planted areas — $15,000
- Purchase of additional trees, labour and fertiliser — $ 5,000

The savings have been in not having to mow the planted areas:

- Time	6 hours/cut
- No. of cuts/month	2
- Cost (based on Minter Research of $16.03-$31.37/cut)	$384-$752
- Fertiliser	$500

The savings in dollar terms are relatively small, however, there has been an improvement in the visual aesthetics and 144 hours of labour that can be allocated to other tasks around the golf course.

To determine the potential for cost savings in mowing the golf course, an audit of the golf course layout and the time and costs associated with mowing the various areas needs to be conducted. A checklist can be used as part of the audit process.

Table 10.6: Golf Course Mowing Audit

	Fairway	Rough	Green	Out of play areas
1. Area (ha)				
2. Surface quality required				
3. Frequency of mowing (mowings/month)				
4. Time per mowing (hrs/mowing)				
5. Labour costs per mowing ($/mowing)				
6. Fuel cost per mowing ($/mowing)				
7.Equipment maintenance costs				
8.Depreciation on equipment				
9. Insurance				
10. Machinery tasks other than mowing e.g. - vacuuming & disposal of clippings - cleaning up of limbs, leaves, pine cones				
11. Potential for implementing other options (L, M, H)* - PGRs - Reduced cutting frequency - Change vegetation type - Change machinery type				

* *L=low, M=medium, H=high*

10.3 MACHINERY NOISE

Many golf courses are within urban areas and are often constructed in conjunction with housing sub-divisions. Noise from operating machinery is an increasing concern as it affects the operation of the golf course.

Council authorised officers are likely to be the first point of contact for many enquiries or complaints about noise. It is good policy for golf superintendents to discuss such issues with their local council officer and seek ways to minimise such disturbance.

Councils may consider that machinery noise significantly impacts adjacent residential premises and may issue a Notice to the golf club to control the level of noise. Two forms of Notice are possible, a Prevention Notice and a Noise Control Notice.

The Prevention Notice is designed to control actions that result in noise and may require the production of an environmental management plan as a first step where it is initially unclear what management actions are required to reduce noise below what council consider undesirable. There are administrative costs payable by the golf club for the issue of this Notice plus compliance costs that are detailed in an associated Compliance Cost Notice. There may be additional costs in managing mowing activities in compliance with the notice as they may involve mowing sensitive areas at particular times which may have efficiency implications for the use of resources.

A Noise Control Notice seeks to control noise by stipulating a noise level not to be exceeded at a specified point, usually a residential property boundary and is used when the solution to the noise problem is simple. In issuing this Notice council needs to be clear that such a level is achievable and represents reasonable protection for residents. Again this Notice may have efficiency implications for the management of the mowing resource.

There is available an electric greens mower and this type of machine may provide an alternative to petrol and diesel powered mowers in some situations. At the Riverside Golf Club (South Australia), a Ransomes Eplex 2 electric mower is used for the express purpose of minimising noise disturbance on adjoining properties. The cutting reels of mowing equipment can also provide a high level of noise if not adjusted correctly or beeded in.

10.4 POLLUTION AND ENERGY ALTERNATIVES

General pollution issues related to noise, emissions, wash down areas and machinery maintenance facilities are requiring golf courses to upgrade facilities and machinery manufacturers to develop new ‘low pollution’ machinery.

In response to environmental issues such as leaks, emissions and noise, machinery companies are now investigating alternative energy sources. The TORO company have produced the following information detailing the alternatives that they are investigating.

Batteries: The energy needed by the machine is provided by a collection of batteries. The number of batteries is determined by the voltage that is desired. Typical voltages are either 36 or 48 volts.

Advantages	Disadvantages
• Zero emissions • No hydraulic leaks • Conventional technology (lead acid) • Similar to golf cars • Low maintenance required • Energy source generates no noise	• Heavy and bulky • Short run times -50 to 100 times less than gasoline (on a weight basis) • Long recharging time (typically overnight) • Advanced (non-lead acid) batteries are still developmental

CNG/LPG: The energy source for a conventional engine is either compressed natural gas or liquefied petroleum gas. Both CNG and LPG are a conventional hydrocarbon fuel, but they burn cleaner than gasoline.

Advantages	Disadvantages
• Lower emissions • Longer engine life • Less engine maintenance e.g. fewer oil changes • Fuel readily available (natural gas or propane) • Technology available today	• Tanks are bulky and heavy • More frequent refueling required • More difficult fueling procedure • New fuel storage infrastructure required • Additional cost in engine fuel system • Engine must be larger to produce the same horsepower

Fuel Cells: Fuel cells are electro-chemical devices that are similar to lead-acid batteries. They use different chemical reactions to generate electricity. The two reactions that are being aggressively worked on today are the hydrogen-oxygen reaction and the zinc-oxygen reaction.

Advantages	Disadvantages
• Zero emissions • Quiet • More energy per pound of weight than lead-acid batteries • Easily and quickly refueled	• Developmental (not yet available) • Safety questions • New infrastructure to deliver the fuel • More difficult fueling procedure • Slow to respond to varying loads • Currently expensive

Genset: The machine can be powered by an engine combined with a generator set. The engine supplies the energy which is converted to electrical energy by the generator. Electrical energy then powers the machine via electric motors.

Advantages	Disadvantages
• No hydraulic oil leaks • Easily re-fuelable • Loading on the engine is smooth • Easily controlled • Burns commonly available fuels (gasoline or diesel)	• Engine has emissions and noise similar to engine driven product • Electric drive system more costly than conventional drives

Hybrid: A hybrid combines the best features of two energy sources. For example, the primary energy source (a genset or a fuel cell) is sized to be capable of supplying the average power that is needed. Additional peak load requirements, such as climbing hills, are supplied by lead acid batteries. The primary energy source acts as a battery charger to charge the lead-acid batteries whenever the loads are below average.

Advantages	Disadvantages
• Engine runs at constant load and speed can he optimized to perform best under those conditions • When no load is demanded, no energy is consumed • Potential for low emissions and high efficiency • Long runtime between refueling • Easily refueled • Lighter than battery only • Engine powered version could be done with today's technology • No hydraulic fluids to leak • Stealth mode (battery only mode) possible	• More costly than engine only or battery only • Heavier than engine only • More bulky than engine only • Fuel cell version requires some technological development in fuel cells to be possible

While most of this work is still developmental it does provide a vision for the future.

10.5 MACHINERY MAINTENANCE

It is difficult to find any detailed information related to the eco-efficiency of machinery maintenance. However, the following points can be made (*Australian Turfgrass Maintenance*, 2001):

- Good maintenance reduces machinery downtime. Machinery downtime increases costs because employees who don't have use of the machine are being paid while not performing work.
- Well-maintained machines remain in service longer, reducing the cost-per-year figures for the individual type of machine.
- Well-maintained machines command a higher trade-in or sale price. This factor alone may compensate entirely for the increased costs imposed by increased maintenance schedules and investment in parts (more filters for more frequent oil changes.)
- Finally, there's the intangible factor that employees much prefer working with efficiently-running, well-maintained machines which do a better job. They may perceive greater respect from their employer as a result of giving them good equipment to use. They may also treat the machine with greater respect, and thus may be involved in fewer cases of damaging the machinery by indifference. This last one is difficult to quantify, but might be the most important factor of all, since human error and machinery abuse are so costly.
- Properly maintained machines will always pollute less.
- It is well known that properly sharpened mowers (whether reel or rotary) produce a more uniform cut while causing less stress to turf plants which in turn may require less fertiliser and fewer pesticides to maintain vigor.

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SECTION ELEVEN

Education and Training

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SECTION 11:
Education and Training

11.1 INTRODUCTION

Improving the environmental management of golf courses requires an effective education and training program for all staff. The adoption of best environmental management practices can only come about with education and training so that staff are aware of:

- the aims and objectives of the operation of the golf course facility;
- the benefits to the course, golfers and the community of best environmental practices;
- the legislative requirements governing golf course management;
- good environmental stewardship (including being able to recognise environmental problems and implement solutions); and
- safe operating procedures.

Staff training can be undertaken by various means depending on the needs of management and the individual. Specific areas of training may include:

- pesticide spraying and chemicals management;
- irrigation;
- stormwater management;
- soil management (including erosion and sediment control);
- mowing;
- fertilising;
- vegetation management and
- equipment maintenance.

Written procedures to be followed when carrying out designated duties are necessary, as are appropriate induction sessions to ensure that staff have an adequate understanding of what is expected. On-going education and training, both on the job and off the job, will ensure that staff maintain and extend their skills and motivation and are able to comply with legislative requirements and environmental best practice.

The Rural Training Council of Australia (RTCA) is the peak industry body overseeing the turf industry's training agenda. In 1998, the RTCA released the National Horticultural Training Package, which gave details of six vocational levels of competency, from Groundsman through to Greens Manager.

The previous two training packages were reviewed during the past two years with extensive industry and training provider input and three new packages have been developed. These are the Conservation and Land Management Training Package and the Rural Production and Amenity Horticulture Training Packages. See the RTCA website for further details at www.rtca.com.au.

The first step in ensuring that any business is operating efficiently is to ensure that worker skills are adequate to meet work challenges. When reviewing the efficiency of operation of a business, therefore, it is necessary to undertake a skills audit of all staff. This benchmarks the skills base and clearly identifies the future training programs required. The benefit of the new National Horticultural Training Package, is that it allows golf clubs to benchmark their skills base against unbiased national turf industry competency standards. With this knowledge, they can develop training programs, either in-house or through an external provider, to upgrade the skill levels to maximise productivity and efficiency. Indeed, the increased flexibility of the package enables clubs to negotiate with educational providers to develop flexible training courses, some of which can be delivered in the workplace. This has the potential to reduce the time-cost burden of losing apprentices and trainees to attend training at TAFE or equivalent institutions for skills that can best be learnt on the job. This is not to say that all turf skills can or should be learnt on the job only, but that there now exists a greater flexibility to undertake training at the same time as maximising all staff members' productivity in the workplace.

The Amenity Horticultural Training Package is also an excellent tool for developing position descriptions for each layer of staff. It clearly spells out the specific competencies (skills) required for each position. This is particularly useful in creating an induction booklet for each position. Very few golf courses have an induction booklet for new employees and it is strongly recommended that all golf courses develop such a booklet. The induction booklet should include:

- overall mission statement and philosophy for the facility;
- description of the facility;
- occupational health and safety procedures;
- operational procedures (e.g. before task is undertaken the equipment is checked and cleaned on completion);
- identification of environmentally-sensitive areas and special precautions;
- legislative framework under which the golf course operates (key laws and regulations e.g. *POEO Act 1997*, *Pesticides Act 1999*, the *Pesticides Amendment (Records) Regulation 2001* and the *Pesticides Amendment (User Training) Regulation 2003.*

Good staff training ensures that resources will be used efficiently. Water and fertiliser use, pest control and land management are dependent on well-trained staff who understand the principles behind what they are doing and the environmental and economic benefits of good practices.

Recent NSW developments affecting golf course staff

The NSW DECC has introducing a new law requiring compulsory training for all commercial pesticides users. This is the Pesticides Amendment (User Training) Regulation 2003). It requires commercial users to have a qualification that shows they are able to apply and manage pesticides correctly. People who have not been trained will have a period of possibly two years to get trained or to have their current skills recognised. People who are qualified have to be reassessed every five years. There are a range of training options -in most cases a two day course (eg SMARTtrain or ChemCert) based on the national Horticulture Training Package, will be appropriate. Alternatively, staff may apply for recognition of prior learning (RPL) and be assessed against the relevant competencies by appropriate Registered Training Organisations. Superintendents should ensure that all staff using pesticides are trained (or assessed as competent) as required by the new Regulation. (See the *Pesticides Act 1999* information in Chapter 4.2 for more detail.)

Training checklist

- Contact the Rural Training Council of Australia to get a copy of the newly endorsed Amenity Horticultural Training Package.
- Determine numbers of persons required at each vocational level.
- Undertake a formal assessment of existing skills base against the National Turf Industry Competency Standards (a registered training organisation can assist with this).
- Compare existing skills with those required.
- Develop training programs to fill gaps between the skills required and those already available in house.
- Contact private and public providers to develop flexible delivery of training or even consider providing some training in-house.

11.2 THE ROLE OF GOLF COURSES IN EDUCATING AND INVOLVING GOLFERS AND THE COMMUNITY TO ACHIEVE BEST ENVIRONMENTAL PRACTICE

As noted in previous chapters, golf courses can be a ‘green oasis’ providing vital habitats for indigenous flora and fauna, especially in heavily urbanised areas. Corridors for wildlife can be incorporated into construction and reconstruction works and the construction of wetlands can serve to strip nutrients from contaminated stormwater as well as providing home to native birds and animals.

In order to improve the environmental management of the golf club, it is vital to engage and educate golfers and the wider community. This will not only ensure good relationships but also education on a range of environmental issues such as encouraging an increase in local flora and fauna and their role in maintaining/ increasing bio-diversity. Many golf courses have utilised the services of outside agencies, both government and non government, to assist them in improving environmental practices and engaging the local community. Communication tools such as regular newsletters, a session on the local radio and hosting school excursions can all be valuable in involving the local community.

It is useful to remember that in order to effect change you often need assistance and allies. As the *Audubon Cooperative Sanctuary Program for Golf Courses* illustrates in its section on Outreach and Education, it is vital to engage your local community. They can provide a conduit to reach golfers and committees and management and can become involved in bush regeneration, monitoring native animals and birds, and in engaging the local media.

Andrew Baker, Claude Crockford Environmental Award winner, 2001, confirmed this in his statement:

> 'Recognising the need for support from the membership base, staff and community, the ‘outreach program’ initiatives set down by Audubon became critical in facilitating the programs and once convinced of the obvious benefits of the long-term strategies that we hoped to put in place, even groups that were initially reluctant to embrace the changes, played a key role in the lengthy certification process.'

Workshop participants attending from various sectors of the turf industry, including Golf Courses, Council Officers and the AGCSA.

As demonstrated in the Long Reef case study (Chapter 8 Native Vegetation and Wetlands) working with golfers, the local community and other organisations can be one of the most effective ways of initiating environmental improvements. This becomes a mutual learning program, with small steps taken to achieve specific outcomes, which in turn can inform, educate and lead to further environmental change.

Some government agencies that may be able to assist you include:

- The Australian Museum
- Taronga Park Zoo
- National Parks and Wildlife Service
- NSW Department of Planning
- Your local council environment staff
- NSW Department of Environment and Climate Change
- Local catchment management boards
- NSW Fisheries
- Sydney Water

A range of non government organisations (e.g. conservation groups, local environment groups) are invaluable in providing expertise and enthusiastic support including:

- Australian Conservation Foundation
- Society for Growing Australian Plants – NSW
- Total Environment Centre
- National Parks Association of NSW
- Local environment centre
- WIRES
- Nature Conservation Council of NSW
- Birds Australia
- Greening Australia
- Flora for Fauna
- Streamwatch

11.3 EDUCATIONAL CONTACTS

The following organisations provide advice and information on the implementation of the National Horticultural Training Package and where to find assessment services:

Rural Training Council of Australia
PO Box E10 KINGSTON ACT 2604
Tel. (02) 6273 2514
Fax (02) 6273 4811
Web: www.rtca.com.au

Australian Golf Course Superintendents' Association
Suite 1, Monash Corporate Centre
752 Blackburn Rd, Clayton North Vic 3168
Ph: (03) 9548 8600
Email: info@agcsa.com.au
Web: www.agcsa.com

USEFUL WEBSITES

www.bom.gov.au
www.environment.nsw.gov.au
www.drummuster.com.au
www.usga.org
www.gcsaa.org
www.lib.msu.edu/tgif

GLOSSARY

acid sulphate soils (ASS) – soils that are rich in iron sulfides, particularly pyrite (FeS_2). ASS are associated with low lying areas and swamp soils and when exposed to air produce sulphuric acid with pH's commonly less than 1.

active ingredient – the chemical in a pesticide formulation primarily responsible for its phyto-toxicity to the target pest, and which is identified as the active ingredient on the product label; abbreviated ai.

Biodiversity – is the variety of all life forms: the plant, animals and micro organisms, their genes and the ecosystems of which they are a part.

biological control – the control or suppression of noxious organisms or pests by the action of one or more natural or introduced organisms or biological agents through natural means, or by manipulation of the organism or environment.

cation exchange capacity – the sum of exchangeable bases plus total soil acidity at a specific pH value, usually 7.0 or 8.0; abbreviated CEC.

compaction, soil – an increase in the soil bulk density, and concomitantly a decrease in the soil porosity due to the application of mechanical forces to the soil.

controlled-release fertiliser – a fertiliser with a rate of dissolution less than that obtained for completely water-soluble fertilisers; it may involve (a) compounds that dissolve slowly, (b) materials that must be decomposed by microbial activity, or (c) soluble compounds coated with substances highly impermeable to water.

cool-season turfgrass – a cold-tolerant turfgrass species best adapted to growth during cool, moist periods of the year, and commonly having a temperature optimum between 16-24ºC; includes the *Agrostis, Festuca*, *Lolium* and *Poa* species.

denitrification – conversion of nitrate-N into gaseous N forms, N_2 and N_2O which are lost to the atmosphere.

electrical conductivity – the conductivity of electricity through water or an extract of soil; it is used to estimate the soluble salt content in solution; abbreviated EC.

evapotranspiration rate – the amount of water evaporated from a turf area per unit of time; expressed as mm/day; abbreviated ET.

fertigation – the application of nutrients dissolved in water to a growing medium around plant roots. Usually applied through the irrigation system.

herbicide – a chemical substance or cultured biological organism used to kill or suppress the growth of plants.

irrigation, automatic – a water application system in which values are automatically activated, either hydraulically or electrically, at times preset on a controller; the system may or may not be integrated with an automatic sensing unit.

leaching – movement of nutrients, salts and pesticides through the soil due to the action of water.

mineralisation – conversion of organic-N through microbial action to mineral forms, predominantly ammonium (NH_4) and Nitrate (NO_3).

parts per million – the number of parts by weight of a given compound in one million parts of the final mixture; abbreviated as ppm.

pathogen – a disease-inducing agent such as a fungus or virus.

pest threshold damage level – the level of pest injury that requires implementation of a management tactic.

pesticide – any chemical or mixture used to control unwanted plant or animal life to protect desirable organisms.

phytotoxicity – the poisonous effect of a chemical that causes death or injury to plants.

pH, soil – the pH of a solution in equilibrium with soil.

plant growth regulator – a substance used for controlling or modifying plant growth processes without severe phytotoxicity; abbreviated PGR.

postemergence herbicide – a chemical applied to the foliage of a weed after emergence from the soil.

preemergence herbicide – a chemical applied prior to the emergence of a weed from the soil.

rhizome – an elongated, jointed, underground stem that can produce roots and shoots at each node.

salinity soil – the amount of soluble salts in a soil; the conventional measure of soil salinity is the electrical conductivity of a soil water extract.

selective herbicide – a chemical that is more toxic to some plant species than to others.

sodium adsorption ratio – a relation between soluble sodium and soluble divalent cations that can be used to predict the exchangeable sodium fraction of soil equilibrated with a given solution; abbreviated SAR.

surfactant – (1) a substance that lowers the surface tension of a liquid. (2) surface-active material that improves the emulsifying, dispersing, spreading, wetting or other properties of a liquid by modifying its surface characteristics.

tank mixing – the mixing of two or more pesticides in the spray tank at the time of application.

thatch – an intermingled organic layer of dead and living shoots, stems, and roots of grasses that develops between the turf canopy of green vegetation and the soil surface.

topdressing – a prepared root zone mix added to a turfgrass surface and worked-in by brushing, matting, raking, and/or irrigating to (a) smooth a closely mowed putting green surface, (b) firm a turf, (c) enhance decomposition, or (d) cover stolons or sprigs during vegetative planting.

volatilization – evaporation of a liquid or solid. Usually associated with pesticides and fertilisers.

warm-season turfgrass – a heat-tolerant turfgrass species best adapted to growth during the warmer periods of the year, and usually dormant during cold weather or injured by it; commonly having a temperature optimum between 27-35ºC; e.g. *Axonopus, Cynodon, Paspalum, Stenotaphrum*, and *Zoysia* genera.

wetting agent – a surface-active substance that reduces interfacial tensions and causes spray solutions or suspensions to make better contact with treated surfaces in terms of both spreading and penetration; a few types of wetting agents are effective in correcting hydrophobic soil-turf problems.