NATIONAL WATER QUALITY
MANAGEMENT STRATEGY

EFFLUENT MANAGEMENT GUIDELINES FOR AQUEOUS WOOL SCOURING AND CARBONISING IN AUSTRALIA

June 1999

AGRICULTURE AND RESOURCE MANAGEMENT COUNCIL OF AUSTRALIA AND NEW ZEALAND

AUSTRALIAN AND NEW ZEALAND ENVIRONMENT AND CONSERVATION COUNCIL

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PREAMBLE

This document is one of a suite of documents forming the National Water Quality Management Strategy (NWQMS). This Strategy aims to achieve the sustainable use of the nation's water resources by protecting and enhancing their quality, while maintaining economic and social development.

The Effluent Management Guidelines series, covers guidelines for specific industries. Six separate documents deal with specific industries as set out in Figure 1. This document provides national Effluent Management Guidelines for Aqueous Wool Scouring and Carbonising. It sets out principles that can form the basis for a common and national approach to effluent management for the aqueous wool scour industry throughout Australia.

Effluent Management Guidelines					
Dairy Sheds and Dairy Processing Plants in Australia		Intensive Piggeries in Australia	Aqueous Wool Scouring and Carbonising in Australia	Tanning and Related Industries in Australia	Australian Wineries and Distilleries
a) Dairy Sheds	b) Dairy Processing Plants				

Figure 1: Structure of the Effluent Management Guidelines for specific industries

Further information on the National Water Quality Management Strategy is given in Appendix A.

While prepared by a joint ANZECC/ARMCANZ working group these guidelines are designed primarily for the Australian situation, in recognition of the different legislative framework in New Zealand. However they could serve as a basis for discussion in New Zealand on the issues addressed in the guidelines.

1 INTRODUCTION

During 1995-96 Australia produced 646,000 tonnes of shorn greasy wool from 123 million sheep on 60,000 properties. Exports totalled 697,000 tonnes (as greasy equivalent) of greasy, scoured, carbonised, tops, noils, and wastes, with an extra 238,000 tonnes as wooled sheepskins. The total value of exports was $3475 million including the woolled sheepskins. Capacity exists for 278,000 tonnes greasy (or about 30 per cent of shorn wool) to be processed in Australia to an early stage, predominantly by scouring and carbonising, but including carding and combing to produce wool top. A total of 142,100 tonnes of processed wool was exported in 1995-96, (91,400 tonnes as scoured wool and 50,700 tonnes as tops). There is increasing interest in the expansion of value-adding processing of wool within Australia.

There were 23 early stage wool processing plants in Australia in 1994, of which 19 scoured wool. A number of firms also carbonised wool (removing vegetable matter with acid). Some Australian plants are among the largest in the world and are leaders in the introduction of new technology and innovative products.

Scouring adds value to wool by removing contaminants from raw or greasy wool fleeces to provide clean fibre suitable for a range of uses. The different processes for scouring wool are:

- the traditional aqueous process which is widely used in Australia
- an organic solvent process which is less common and can have a final aqueous wash.

These Guidelines concentrate on aqueous wool scouring, the dominant process used in Australia. The general principles will apply if there are aqueous discharges from hybrid solvent/aqueous wool cleaning operations.

A range of downstream wet-processing operations can be conducted on the cleaned wool after scouring, such as backwashing in topmaking, dyeing, bleaching, insectproofing and shrinkproofing. Management of effluents from these processes is not included in this document as they are quite separate operations.

Both the Report of the Wool Industry Review Committee (the Garnaut Report), and the Report of the Wool Processing Task Force, recommended that national guidelines for effluent discharge from early stage and later-stage processing in both urban and rural areas be developed so as to achieve an Australia-wide approach to developing environmental requirements and standards for wool processing facilities.

1.1 Objective of the guidelines

The objective in developing the *Effluent Management Guidelines for Aqueous Wool Scouring and Carbonising in Australia* (hereafter referred to as 'the Guidelines') is to ensure a nationally consistent approach to effluent management for the wool scouring industry throughout Australia.

The Guidelines can serve as a basis for sustainable resource development extension programs and for negotiations between regulatory authorities, local government and the industry, on conditions for managing, monitoring and reporting for effluent management that should apply at the regional level. They are sufficiently flexible to serve as a framework for developing both codes of practice, and general industry agreements, as well as the range of legislative controls around Australia. It is not practicable to produce guidelines which will be immediately applicable to licensing in all jurisdictions without adaptation to and discussion of local needs and conditions.

These Guidelines would be one of a number of documents that may need to be used for the overall environmental management of a particular wool scour, since they deal with effluents, and associated solid components including sludge, not total site management.

The Guidelines will be reviewed as appropriate, but it could be reasonably expected that this would be within three years.

1.2 Environmental objectives

The Guidelines' main environmental objectives are that the proper siting, establishment and operation of wool scours should:

- maintain the environmental values of surface and groundwaters, including their ecology, by minimising the discharges of effluents containing organic matter, nutrients, salts or chemical constituents;
- minimise the effect of effluent addition to land, which may lead to the degradation of soil structure, salinisation, waterlogging, chemical contamination or erosion; and
- avoid off-site nuisance or interference with amenity, such as odours associated with inappropriate or poorly-operated waste treatment processes.

Achievement of these environmental objectives requires that wool scour operations throughout Australia should be managed to protect:

- surface waters
- groundwaters
- soils
- vegetation
- public amenity.

The main emphasis of these Guidelines is water quality protection. Achievement of these environmental objectives, and the specific objectives in Section 4, should help ensure that wool scouring operations are ecologically sustainable both in the short and long term.

1.3 Application of effluent management guidelines

These Guidelines are intended for use by the wool scouring industry (including consultants), regulators, planning authorities and the broader community.

The industry

The Guidelines aim to:

- assist operators of wool scours to minimise and as far as possible use, the effluent they produce
- prevent the unacceptable degradation of water, land and environmental quality.

The Guidelines should be consulted in conjunction with existing regulations, where extensions or new developments are planned, or where environmental protection at existing operations is to be enhanced.

Regulators and planning authorities

Effluent Management Guidelines for Aqueous Wool Scouring and Carbonising in Australia should provide the framework where guidelines or codes of practice are to be developed for the regulation of wool scours. Any such State or local guidelines should be consistent with the Guidelines. Existing codes of practice or regulations should be consistent with and at least as stringent as these Guidelines.

In general, State, Territory, regional and local government guidelines, laws and regulations will be more detailed than these Guidelines to take account of specific circumstances of the aqueous wool scouring and carbonising industry in different places. Local knowledge and data specific to individual wool scours is essential to manage wool scours responsibly.

The broader community

Integrated catchment management is increasingly becoming the "umbrella" for sustainable natural resource management. It provides the framework for the community, industry and government to work together to overcome environmental and resource management problems.

This document provides information which will help communities to participate in an informed manner in integrated catchment management, including decisions on new or existing wool scouring developments and local resource management issues. Development of catchment-based plans and strategies is central to integrated catchment management.

Further information

For further information relating to the effluent management, refer to other National Water Quality Management Strategy documents, or the sources listed in Appendices C and D.

The development of detailed guidelines and environmental codes of practice is the responsibility of relevant State and Territory authorities. Proponents are thus encouraged to seek advice from the relevant State and Territory authorities about current regulations and codes of practice when new developments are being contemplated, or when the effluent management system of existing operations is to be upgraded.

These guidelines should apply immediately to any expansion and new developments, and be phased in for existing facilities to timetables agreed with State and local government authorities.

2 PRINCIPLES OF ENVIRONMENTAL MANAGEMENT

The main principles of effective environmental management of effluent, in order of importance, are:

- avoidance or elimination of excessive waste generation through improved planning
- optimisation of waste management processes
- effective and feasible recycling and reuse of effluent
- disposal of effluent where its use is not practicable, in a manner that will not cause short or long term adverse environmental impact.

A fundamental consideration for sustainable management of wool scour effluent should be the development of an Environmental Management Plan through the implementation of an Environmental Management System. In some States an operator can be required to produce an Environmental Management Plan as a stand alone document, not as part of an Environmental Management System. The amount of detail provided in the plan will depend on the size of the enterprise, siting considerations in relation to neighbouring communities and the environmental sensitivity of the location such as proximity to surface and groundwater. The Environmental Management System provides for the management, administration and monitoring framework for an operation's environmental aspects. It includes the principles of Total Quality Management and should incorporate the principles of risk management.

In August 1995, the International Standards Organisation (ISO) released the draft international standard ISO 14001 on *Environmental Management Systems: Specification with guidance for use*. In late 1995 ISO 14001 was published as an interim standard within Australia and New Zealand by Standards Australia. This standard can be used to provide guidance when implementing an Environmental Management System.

The Environmental Management System should incorporate the principles of cleaner production to minimise the adverse environmental impacts of the production process. In the context of these guidelines, cleaner production involves the use of:

- better housekeeping
- improved management practices
- state-of-the-art in-plant production processes
- the concept of environmental management of all aspects of the entire production process, from the raw materials to finished product including any associated waste.

Effective effluent management should be seen as an important part of a wool scouring operation, and should be allocated an appropriate share of management effort and expenditure. Good communication within the operation is important for increasing the overall efficiency of the operation, including effective environmental management, ensuring that problems are identified early and rectified before they become significant.

To achieve the objectives of these Guidelines, it is important the Environmental Management System for the operation considers:

- possible future expansion for both existing operations and new developments
- other actual or proposed land uses and activities in the catchment or local area.

Development of an Environmental Management System and/or Plan should involve consultation with regulators, planning authorities and the broader community. State and Territory environment protection authorities can provide information on the development of Environmental Management Systems and/or Plans.

It is strongly recommended that professional consultancy advice be sought in the development and implementation of an Environmental Management System, and that all applications for a new or expanded wool scour operation should be accompanied by a plan for such a System.

3 GENERAL CHARACTERISTICS OF WOOL SCOURING WASTE

Wool scouring effluents contain soil particles, pesticides, wax and sweat (the source of potassium) produced by the sheep itself, and additives used in the scouring and related processes. The amounts of soil, wool wax and vegetable matter present on raw wool depend on where the sheep were grazed and the breed, and cannot be minimised by the scouring plant. In Australian merino fleece, the amount of soil ranges from 6 to 44% with an average of 20%.

Sources and types of effluent from wool scouring operations using a conventional suint bowl scour are summarised diagrammatically in Figure 2.

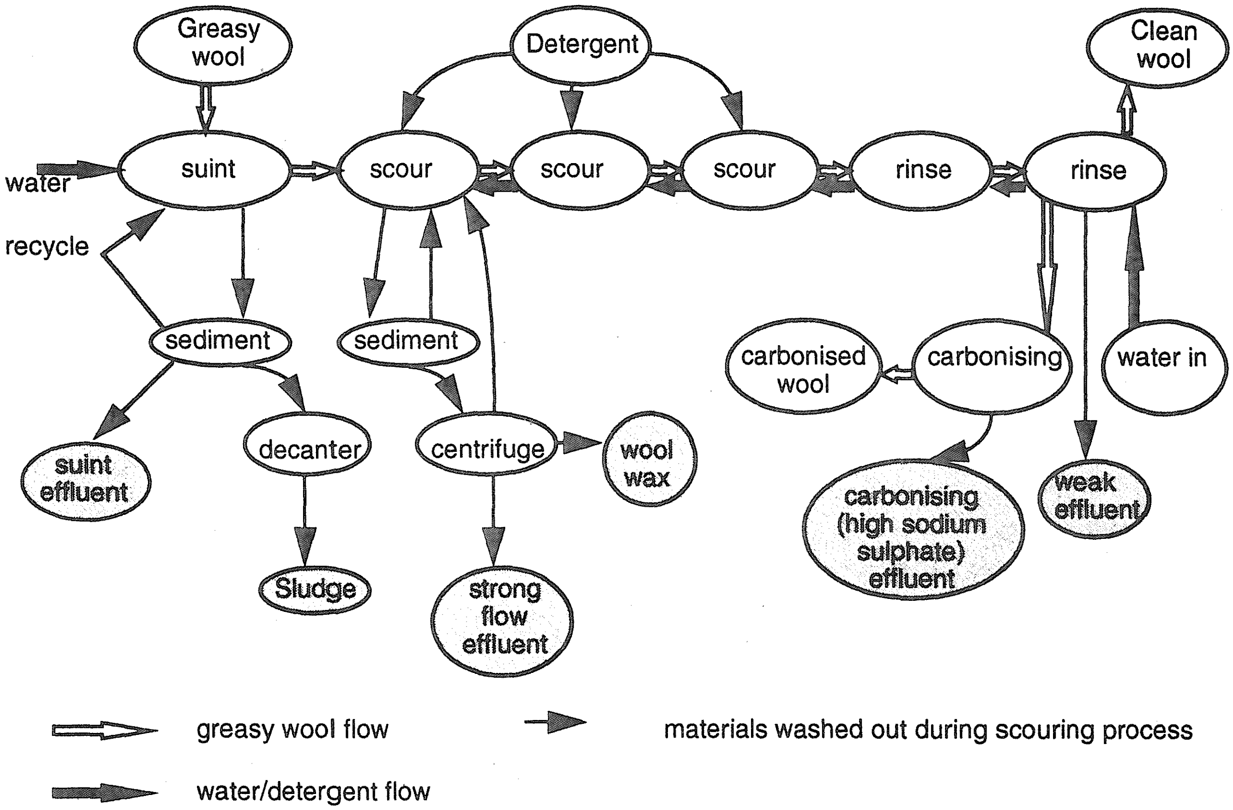

Figure 2: Broad diagrammatic representation of wool scouring operation, showing sources and types of wool scour effluent.

Up to 50 per cent of the soil is extracted in the suint bowl and most of the remainder in the front three scouring bowls. About 40 per cent of the ingoing soil can be recovered from the suint and scouring liquor by centrifuging.

Wool wax is not as quickly biodegradable as some other organic wastes, and as much as possible should be separated before the effluent is treated further. In Australian merino fleece, the amount of wool wax ranges from 10 to 25 per cent by weight with a mean wax content of 16 per cent. The mean wax content is 10.6 per cent for crossbreds.

The wool wax remains in emulsion in the strong flow scouring liquors. This emulsion also contains some suint and traces of pesticides. Depending on the efficiency of the extraction process and the type of wool being scoured, 20-50 per cent of the wax may be recovered as an anhydrous wax by multi-stage centrifuging. This may be further refined into lanolin and other products.

Scour effluents contain detergents. Their biodegradability depends on which detergent has been used, but attention should be given to their degradation products. Where there is concern about build-up of degradation products from detergents, scours should use products acceptable to the local regulating bodies.

Scour effluents may also contain small amounts of residual pesticides from sheep fly and lice treatments, typically organophosphates and synthetic pyrethroids which are degradable. Their concentration in wool scour effluents will vary and be difficult to quantify in many cases without sophisticated analytical equipment. With the abolition of the registered use of organochlorines and arsenical pesticides and with active analysis and traceback programs, Australia now has wool clips which are virtually free of these pesticides.

Sequestering agents, used to soften water, may also be present in the effluent.

Table 1 shows the composition of primary treated wool scour effluent. The values in Table 1 are averages only. Site specific information on the particular effluent stream should be obtained for modelling purposes when developing effluent management processes.

It should be noted that the characterisation of the effluent(s) of a particular enterprise is fundamental to the operation and management of that enterprise and for adequate assessment for any land application program. Collection of data by wool scour operators for the purposes of characterisation of the effluent is essential.

Table 1. Composition of Wool Scour Effluent*

Component	Amount (mg/L)
Wool Wax	3000-6000
Suint	3000-6000
Soil	4000-7000
Pesticide	<1
Biochemical Oxygen Demand (BOD)	2500-5000
Chemical Oxygen Demand (COD)	15000-30000
Suspended Solids (SS)	5000-10000
Total Nitrogen	200-500
Potassium	1000-1500
Ammonia N	40-120
Phosphorus	20-50
Total Surfactants	300-600
Sulphide	<1
Sulphate	30-100
Electrical Conductivity (EC)	1250-4000 µsiemens cm^{-1}
pH	7.5

*Data from Bateup, B O, Christoe, J R, and Russell, I M, CSIRO Division of Wool Technology, 1995. Refers to primary treated effluent. Assumptions: Australian wool, water consumption 10 L/kg greasy wool, primary recovery of 32% of the wax and 42% of the dirt.

Carbonising effluents will also contain neutralised acid (as sodium sulphate) and bleaching agents (usually hydrogen peroxide).

The effluent from wool scouring is characterised by high levels of suint and wool wax, leading to high potassium levels and biochemical oxygen demand (BOD). The volume of aqueous scour effluent ranges from 8 to 20 litres per kg of greasy wool, depending primarily on the type of wool being scoured and in part by the equipment used.

Odour

By its nature, wool scour effluent has the potential to produce odour problems. This potential is exacerbated if effluents are allowed to turn anaerobic. Modern scouring operations produce little odour and there should be little effect on local residents.

4 GUIDELINES

The Guidelines are designed to provide general principles for the nationally consistent environmental management of aqueous wool scours and carbonising plants to protect water quality. The principles can be adapted by individual jurisdictions to take account of their own legislative and environmental requirements for the approval of new projects, setting licensing conditions and the general environmental management of wool scours. They are not intended to provide detailed prescriptive standards.

The important factors in planning, developing and managing wool scours to ensure that they are both economically and ecologically sustainable are:

- site suitability assessment
- design of effluent management systems
- effluent treatment
- use of effluent
- use of solid waste/sludge
- effluent disposal in circumstances where use is not practicable
- monitoring and reporting
- contingency measures.

4.1 Site suitability assessment

Siting has a significant impact on the complexity and cost of effluent treatment, and the management which would be required to protect water quality. Carefully planned siting of facilities, particularly the effluent utilisation areas facilitates the environmental management of an operation. Where possible, the site selected should be one which avoids the need for costly environmental protection measures and which ensures preservation of community amenity.

Objectives

For existing operations:

- to identify site constraints which can result in adverse environmental impacts
- to manage the wool scouring operations through effective use of appropriate practices, techniques and technologies to allow for these constraints
- to enhance or maintain the water quality of relevant water resources based on their agreed environmental values.

For new wool scouring developments:

- to avoid unacceptable environmental impacts on water resources, soils and amenity
- to enhance or maintain the water quality of relevant water resources based on their agreed environmental values.

Guidelines

The following factors should be taken into account when choosing a site.

4.1.1 Existing operations

Existing operations with site constraints (eg. high watertable, particular soil characteristics, and/or topography, presence of incompatible land uses, size of site, availability of services) should consider implementing the following:

- innovative and effective technologies to minimise effluent and allow for its reuse

- effective design of the plant
- effective housekeeping and best management practices
- an effective monitoring system to enable potential problems to be detected early
- replacement of obsolete technology by proven and more cost effective technology
- liaison with regional planning/zoning authorities.

If the operation cannot overcome the constraints, its scale should be reduced to a manageable level, be re-established in a suitable location, or closed.

4.1.2 New developments

Siting of new operations or substantial expansions to existing operations should consider the following:

- the amount of land required for establishing the enterprise, taking into account:
  - estimation of quality and quantity of the effluent and solid wastes/sludges produced at all stages of the process (ie, raw, post treatment, post storage etc)
  - land suitability (including topography, slope, surface soil type and previous landuse practices)
  - characterisation of the soil to determine its suitability for the storage, treatment and application of effluent and other solid wastes
  - type of effluent storage and treatment system to be used
  - future expansions
- climate (including rainfall, prevailing winds, katabatic wind/ drainage, evaporation))
- type of effluent storage and treatment system to be used
- neighbouring landuse, including residential, commercial, industrial and agricultural
- proximity to sensitive sites, including to surface and groundwaters, areas of scientific value, areas of Aboriginal significance and areas containing unique, uncommon or endangered fauna and flora
- the proximity of services and amenities including water supply
- the need for appropriate buffer zones between the enterprise and sensitive areas including waters and residences
- potential beneficial uses of groundwater
- the requirements of the sewerage service provider for industrial waste disposal, if disposal to sewer is planned for plants in urban areas
- other factors outlined in Section 4.4, Use of wool scouring effluent, eg surface runoff/soil erosion.

Once the site has been chosen, it should be benchmarked to:

- develop siting, operational and management systems that ensure the facility is managed to minimise environmental impact
- compare benchmark information with subsequent monitoring information to assess environmental performance.

Performance assessment options

Performance Indicators for site suitability could include:

Existing sites

- onsite development and use of appropriate practices, techniques and technologies are in place

- an acceptable Environmental Management System and/or Plan is in place
- public amenity has been maintained by odour control
- a monitoring program is in place for water and odour (for monitoring of water resources, see the NWQMS documents: *Australian Water Quality Guidelines for Fresh and Marine Waters,* and *Guidelines for Water Quality Monitoring and Reporting).*

New sites

- Best Available Technology has been implemented, where possible at reasonable cost, to ensure environmental protection measures specific to the site have been undertaken.

New and existing sites

- risk management assessment of the site has been undertaken
- assessment has been made of the suitability of the soil and hydrology at the site for wool scouring operation
- protection measures specific to the site have been established
- adverse impacts on water resources, land and amenity have been minimised
- adequate safeguards for possible system failure are in place.

The proponent's past environmental performance should be considered where approval is to be given for the development of new scours, or for extensions to existing scours.

4.2 Design of the effluent management system

Wool scour operations should incorporate accepted modern technologies and processes. This involves the adoption of technology which has consistently achieved the desired effluent quality levels in economically viable operations. It should also take account state-of-the-art engineering and scientific developments in effluent treatment, as well as opportunities for waste minimisation. It is recognised that good effluent quality is not necessarily dependent on high technology and may often involve simple, innovative solutions. Wool scour effluent management options are represented diagrammatically in Figure 3.

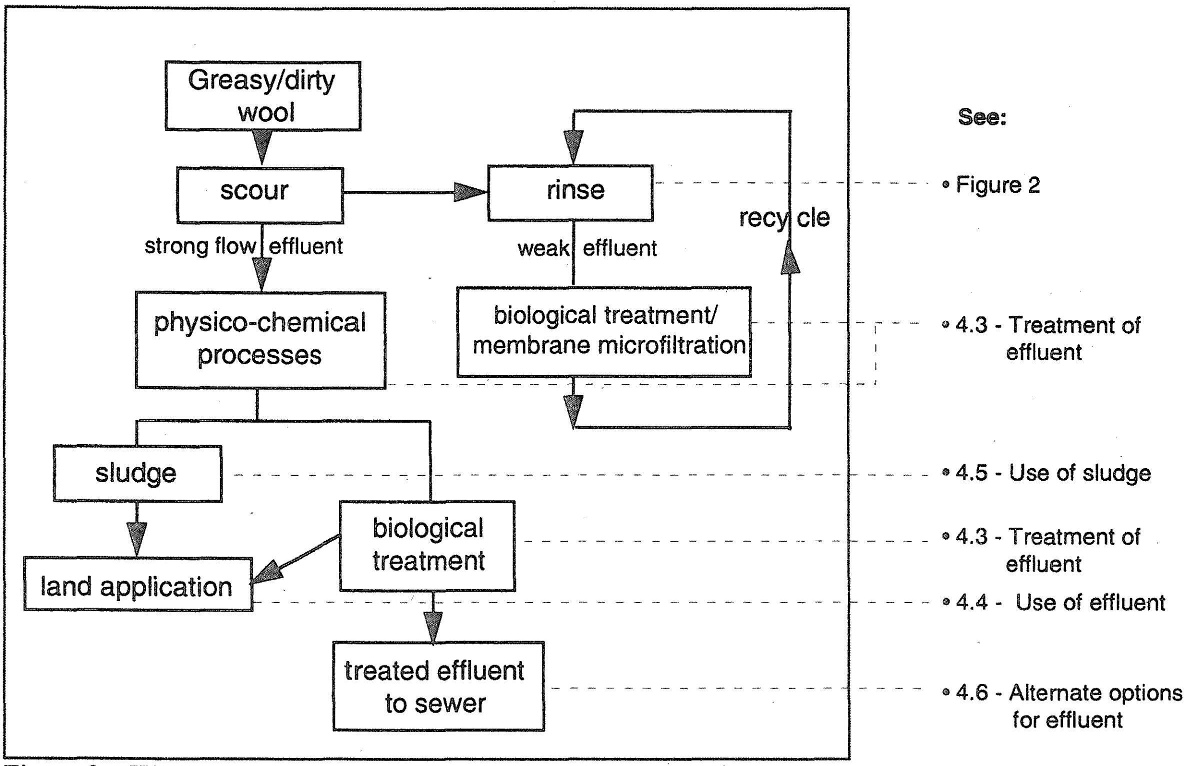

Figure 3: Wool scour effluent management and treatment options.

Objectives

These are to:

- optimise the quantity and quality of effluent, given the expected use of the effluent
- produce effluent of a quality which will enhance its utilisation
- meet regulatory requirements
- design an effluent treatment and management system which includes zero discharge to surface waters and aims at zero discharge to groundwaters. It is recognised that a leaching fraction may be needed to flush salts beyond the root zone
- ensure the various wool scour components including the effluent management and treatment systems are mutually compatible and well-integrated.

Guidelines

4.2.1 Separating stormwater from wool scour effluent

Uncontaminated stormwater flows should be separated from the effluent system, and either collected for use within the plant or directed to watercourses to maintain environmental flows. Separating stormwater flows from the effluent will reduce the volume generated and will improve treatment performance due to more even hydraulic loading.

Contaminated stormwater should be directed to effluent collection lagoons, provided the lagoons have the capacity to handle the extra volumes that may be involved. If the effluent system cannot handle the volume, then the plant should be designed to allow for the separate collection of contaminated stormwater.

In urban areas where wool scours discharge to the sewer, some authorities may require the operation to have the capacity to store all polluted stormwater for discharge after heavy rain. Where the first downpour of rain will flush an open area clean, the relevant authority may accept this polluted water with the discharger being required to divert the following rainfall to stormwater, on the grounds that it is no longer polluted.

4.2.2 Optimising the volume of effluent generated, and enhancing water recycling

The plant should be designed to optimise the overall operation. This can be achieved by ensuring the various components of the plant, including the effluent management systems, are mutually compatible and well-integrated. Efficient water use, including recycling, will minimise the volumes of effluent generated and the consumption of clean water. Wool scouring plants should aim to achieve, or go below, water usage of 8-15 l/kg of greasy wool scoured.

4.2.3 Minimising the load of effluent components

Minimising the load of components in the effluent stream should reduce the need for costly treatment, and also enhance opportunities for utilisation. Examples of load minimisation include:

- removal of potential sources of load (eg removal of organic matter)
- chemical substitution (changing the chemical additives in the scouring process)
- electro/mechanical process control through updated engineering techniques enabling the optimum amount of consumables to be added at the various process stages.

4.2.4 Separating the various waste streams

Attention should be given to separating the waste stream components according to their characteristics and specific treatment needs to improve the resultant effluent quality. This would obviate the need for costly treatment and enhance opportunities for reuse. This can be achieved by:

- separating the wastewater streams so that each may receive specialised treatments
- maximising the performance of soil and wool wax recovery devices to achieve continuous operation and minimise discharges in aqueous waste streams

4.2.5 Effluent treatment systems

The selection of an effluent treatment process will depend mainly on the components of the effluent and their concentrations, available accepted technologies, the desired final quality of the effluent, solid wastes/sludge and cost. The range of available treatment options is discussed in sections 4.3.

4.2.6 Effective effluent containment and storage

Storage and treatment tanks and lagoons at rural and semi-rural scours should be designed to safely contain their maximum operational load and comply with local regulations, including provision of sufficient freeboard. This should take into account the maximum volumes of effluent to be stored during seasons when land application may not be possible because of climatic conditions, as well as increased effluent volumes resulting from above average rainfall events (relevant authorities should be consulted on conditions required to satisfy local requirements). A generally accepted standard is to design any system to cope with the wettest year in ten.

The base should be constructed with low permeability materials or lined with such materials to minimise the leakage of effluent to groundwater resources. In addition, lagoons should be designed and constructed to prevent potential pollution of surface water through runoff.

4.2.7 Controlling spillages

Areas where accidental spillage of effluent or chemical products could occur should be adequately bunded or sloped to drains and directed to storage, or to effluent treatment areas. The installation of an effective alert system for pumps and equipment, will help to avoid the occurrence of spillage. It will enable spillages and equipment malfunctions to be detected and remedial action instituted .

Chemical spills should also be contained and should not be directed to effluent treatment and storage areas.

4.2.8 Preventing contamination of water supplies

When water supply is from a reticulated supply, surface water impoundment or direct from groundwater bores, backflow prevention devices which meet relevant Australian Standards should be installed. Water authorities should be contacted to ascertain any controls on establishing and operating wool scours within declared drinking water source areas.

4.2.9 Odour control

Odours from the site of the wool scour operation can occasionally result in the loss of public amenity. These odours arise from poor design and management of the wool scour. Protecting the community from odours depends on several factors, including:

- the quality of effluent discharge
- the type of effluent treatment systems
- methods used to minimise and treat odours generated from effluent treatment, storage and disposal
- whether effective buffer zones have been considered at all stages of the planning process for the operation, including
    - the distance between sites on the property where operations are undertaken and the surrounding amenities
    - physical barriers, including topography and vegetation
    - climatic conditions, including wind direction, speed and turbulence (eg by plume modelling)
- community consultation and involvement.

By themselves, buffer zones do not protect the community from odour. Most odour problems will be alleviated if the effluent management practices recommended elsewhere in these guidelines are adopted for new and existing wool scours. Proponents, as well as operators of existing wool scours, are encouraged to discuss separation distances for buffer zones, and other related requirements, with the relevant State or Territory agencies or authorities who may have specific requirements, as well as the local community.

When new activities are proposed for sites near established wool scours, it is important to recognise the existence of agreed buffer zones.

4.2.10 Land application of effluent

The ultimate aim of any effluent management system is to sustainably use and assimilate the nutrients, salts, organic matter and water contained in wool scour effluent and solids into the environment by employing crops, pastures and soils. For further details refer to Section 4.4, Use of wool scour effluent.

Performance assessment options

Monitor:

- the volume and characteristics of treated and untreated effluent so that they are kept within sustainable and manageable limits
- quantities of recycled and reused process liquors and effluent
- spillages; ensure they are contained and deal with sources of spillages
- any odours
- effluent and solids application areas, for possible degradation of soil structure, salinisation, waterlogging, chemical contamination or erosion and impacts on groundwater.

Assess the wool scours' overall performance in consultation with the community and relevant government authorities.

4.3 Treatment of wool scouring effluent

Apart from rinsewater which contains little pollution, suitable treatment in a properly constructed and maintained treatment system will be required prior to utilisation of the effluent.

Objectives

To treat wool scour effluent to allow for its use in an environmentally sustainable manner for a particular site.

Guidelines

The treatment systems should permit safe, effective and sustainable land application of liquids and separated solids. For disposal to sewer, the treatment should achieve the quality required by the treatment plant for trade waste. Selection of an effluent treatment system could be based on the factors outlined in Section 4.4 Use of wool scour effluent.

Any treatment system will need to be able to either reduce, or deal with:

- BOD
- salts, particularly potassium
- detergents and pesticides
- total suspended solids
- wool wax (leads to reduction in BOD and potassium)
- odour

Initial on-site treatment may be required for scours in urban locations with access to sewer and limited access to land. The treatment goal will be to meet sewerage acceptance criteria.

The main need will be to reduce BOD on site by removing wool wax from the discharge stream. A variety of processes are available ranging from chemical clarification and biological digesters to evaporation and incineration.

The document NWQMS *Sewerage Systems - Acceptance of Trade Waste (Industrial Waste)* gives further information on this topic.

Where urban sewage treatment is followed by land application, it is important to consider land salinisation due to the higher potassium content of the effluent. In country locations, there is opportunity to use lagoon systems for BOD removal (see next Section). Treatment goals will be to reduce organic contaminants and simultaneously find beneficial uses for the potassium to avoid salinisation effects. Any treatment system needs to be carefully managed and regularly maintained.

Aerobic lagoons and land irrigation processes should be efficient enough to effectively remove most of the organics, detergents and pesticides by settlement and degradation of organic matter. The potassium, which is useful, should pass through unaffected.

It is important to ensure that the expertise required for the efficient management of effluent treatment is available at all times.

4.3.1 Options for the treatment of effluents

Methods which can be used in an appropriate combination to achieve the effluent treatment objectives are:

Physical and chemical treatment

Solids and suspended matter can be separated from the effluent stream by use of techniques such as coarse screening, sedimentation, dissolved air filtration (DAF), or centrifuging. This type of treatment will not only reduce the rate of sludge build up in lagoons and wear on pumps, but should also be a rapid way of reducing the BOD concentration in effluent prior to disposal or reuse.

Chemicals can be used to enhance treatment characteristics, such as settling of solids by pH correction (eg coagulation, flocculation), and to improve treatment performance or suitability for land application.

Care should be taken to ensure any trace elements, such as copper or cadmium which may be present as impurities in the chemicals used, do not have adverse residual impact on organisms in the treatment system and the general environment.

Biological treatment

The most common forms of biological treatment to enhance the break down of pollutants are anaerobic, facultative or aerated lagoons, either on their own or in various combinations. Anaerobic lagoons are generally effective in reducing BOD and suspended solids. However, if they are poorly managed, odour problems can occur. Where anaerobic lagoons are being considered, the relevant State and Territory authorities should be consulted.

Lagoon systems should be designed to take account of quantity, quality and intermittent generation of effluents, the likelihood of odours affecting nearby landowners, and the ultimate disposal/reuse method to be adopted.

4.3.2 Siting and design of treatment lagoons

Lagoon systems are suitable for effluent treatment where topography and soil conditions favour their installation. Some State regulatory authorities may have information on the siting and design of treatment lagoons to prevent surface and groundwater contamination.

Lagoon siting and soils

Lagoons may be installed where the slope of the land is not too steep to cause problems with their construction and where soils are sufficiently impermeable to retain effluents. Impervious liners should be used in lagoon construction where underlying soil permeability is suspect and there is a potential to contaminate groundwater. Great attention must be paid to their installation.

Lagoons should not be constructed where overflows can enter surface waters or natural wetlands. They should not be installed across watercourses. Adjacent surface water runoff should be prevented from entering the lagoon.

Lagoon design and sizing

Lagoons should be designed to cater for maximum hydraulic and waste load and to allow for a wool scours' future expansion. Lagoon systems should be large enough to retain the total volume of wastewater where soils may be saturated for a period, as in areas with a prolonged wet season. Allowance needs to be made for primary lagoons to be taken out of service, solar dried and desludged after about 5 - 10 years of service.

Allowance should be made for any runoff from the catchment of the lagoon and any contaminated stormwater flows from the wool scour.

4.3.3 Capacity of the effluent management system

Planning for any increase in wool scour production needs to consider the capacity of the effluent treatment system to accommodate the possible production increase. Treatment capacity can be augmented in several different ways, including:

- load reduction due to improved housekeeping and/or effluent stream segregation
- chemical or microbiological supplements
- physical pre-treatment processes
- enhanced aeration of lagoons
- anaerobic pre-treatment processes with appropriate controls on gases generated
- expansion of the lagoon capacity
- new wastewater treatment facilities.

Performance assessment options

These include:

- the characteristics of the effluent are monitored before and after treatment to gauge the effectiveness of any treatment
- wool scour effluent is used for land application, eg irrigating crops, pastures and trees
- all polluted runoff has been contained
- surface and groundwater is monitored for ambient levels of salt, BOD, nitrogen, , phosphorus, potassium and pH (refer to recommended levels for environmental values in *Australian Water Quality Guidelines for Fresh and Marine Waters* as a guide)
- soils are monitored for the effect of effluent application, including physical, chemical and biological characteristics
- the effects on public amenity are evaluated by observing buffer zones and noting any public complaints
- crops, trees and pasture are monitored for yield and foliar symptoms, growth rates and health

- records are maintained from which the history of loading of water, nutrients, salts and contaminants can be calculated for all areas where effluent is applied.

4.4 Use of wool scour effluent

Objective

To encourage the use of:

- nutrients
- organic matter
- water values of the solid waste/sludge and wool scour effluents
- trace elements,

where this use is not precluded by other components of the effluents, such as salts and pesticides, in a manner which protects water quality consistent with the environmental objectives.

Guidelines

Generally, land application provides the most efficient means of recycling valuable water, along with the effluent's nutrient and organic components. Suitable treatment in a properly constructed and maintained treatment system will be required.

Issues relating to groundwater protection, soil structure, land contamination, salinity and eutrophication of surface waters will need to be carefully considered on a local/regional basis. Local conditions may limit or preclude the application of effluent via irrigation because of the particular sensitivity of the site with respect to these issues. These issues are considered in the following sections.

Further information on the utilisation of treated effluent by irrigation is available from relevant State and Territory Environment authorities, including the Victorian and NSW Environment Protection Authorities (EPA (Victoria) (1992) and EPA - NSW (1995)).

Note that application of the guidelines alone does not assure adequate protection of groundwater quality.

4.4.1 Land requirement

The amount of land required depends on a number of factors including:

- susceptibility to waterlogging surface runoff and soil erosion
- hydrogeology
- climatic conditions (amounts of rainfall, evapotranspiration, wind speed)
- agricultural and horticultural practices
- the properties of soils (infiltration rate, phosphorus sorption capacity, moisture storage capacity in the root zone and chemical properties and physical characteristics, Electrical Conductivity, Sodium Adsorption Ratio (see p23), Exchangeable Sodium Percentage)
- the anticipated nutrient uptake rate
- quality and quantity of the effluent
- maximum operating life of the application site, determined by the phosphorus sorption capacity of the site and predicted salt accumulation.

The nature of the soils

Long term application of wool scouring effluent at excessive levels could damage soils. To select land for irrigation with effluent, it is important to ensure that the soils have the following characteristics:

- a structure that permits air movement and water penetration
- sufficient depth to permit optimum root development by the crop
- adequate natural drainage, or suitable artificial drainage
- sufficient capacity to hold water for plant use between successive irrigations
- nutrients in sufficient quantities for adequate plant growth
- moderate pH, ie it should be neither too acid nor too alkaline
  - neutral to slightly acid soils are best for most irrigated crops
- ease of cultivation.

It is not always possible to have all of these qualities, and the relative importance of each will depend to some extent on the type of crop to be grown, as well as the characteristics of the effluent.

The most satisfactory soils for efficient irrigation are deep, well structured, well drained soils that range in texture from loam to clay loam. They are generally preferred to sandy soils, which are very permeable, and heavy clay soils, although the range of soils that are satisfactory for crop production under irrigation is quite wide. For effluent irrigation such soils are those that are suitable for irrigated pasture and crop production. Soils for solid waste and sludge application, should be suitable for improved pasture or dryland cropping, able to withstand cultivation without incurring significant erosion or major structural decline, and not prone to waterlogging.

Soils generally considered unsuitable for irrigation include:

- poorly structured clays
- shallow soils with rock, gravel or impeding clay close to the surface
- soils with poor drainage
- soils with a high salt content and low permeability
- coarse silica sand soils (without iron or aluminium-rich fines).

A soil survey is the most satisfactory way of determining the suitability of different soils for the application of effluent to land for pasture and crop production.

Land application rates

Before and during land application, scheduling and application rates based on the properties of the effluent including its salinity and nutrient content, pH and BOD need to be considered. This should be assessed seasonally.

While the maximum application rates for land treatment of effluent will depend on site-specific conditions, they will be limited by one or more of the following:

- hydraulic loading
- nutrient loading/balance
- salt loading
- oil and grease loading.

Guidelines which aim to maintain effluent loading at a rate which, after accounting for rainfall, is balanced by evapotranspiration are inadequate to protect groundwater. This is especially so in areas where rainfall can exceed evapotranspiration over periods which are sufficiently long that excess water (and solutes, such as nitrate and salts) can leach beneath the root zone.

As rainfall cannot be controlled, the only effective way of preventing excessive contamination of groundwater is to ensure that concentrations of nutrients and salt below the root zone remain at an acceptable level. This may require land application of effluent to be suspended during wet periods or seasons.

A nutrient balance can be developed, where the losses from the system are:

- the uptake of nutrient by plants which are removed
- gaseous losses of nitrogen
- and net accumulation of nutrients in the soil.

Such balances should be calculated to account for within-season variations in components of the nutrient budget (particularly plant uptake, net mineralisation and leaching) when determining the application rates. Long term nutrient monitoring of the soil solution below the root zone would provide feedback on sustainable application rates and site management, and complement groundwater sampling at the watertable.

Water budgets

Water budget studies provide a means of quantifying land requirements and the volumes of effluent which may be applied.

Surface runoff/soil erosion

To minimise surface runoff and soil erosion, effluent should not be used on land which is:

- immediately adjacent to streams and water courses
- subject to flooding (flood risk analysis should be undertaken)
- waterlogged or saline
- steeply sloping with inadequate ground cover
- rocky, slaking and highly erodible
- of highly impermeable soil type.

Groundwater

Important factors to consider are:

- groundwater quality
- the depth to groundwater - including perched and seasonal watertables, and soil type - which can influence infiltration rates
- the location, characteristics, and current and potential use of groundwater.

A small increase in infiltration of water from the surface to the groundwater can cause a rise in the level of the watertable. As the watertable rises, it carries the salts in the soil towards the surface, increasing salt levels in the root zone and possibly causing waterlogging. It is unlikely to occur where wool scour effluent is applied to dryland crops and pastures (in permeable soils with a substantial separation between surface and watertable).

Measures to protect groundwater quality will be more onerous where the ambient groundwater quality is capable of providing drinking water supplies or sustains ecosystems. Once contaminated, groundwater is expensive to clean up.

Hydrogeological expertise will be required to evaluate the characteristics of the groundwater beneath the land application area. This will include evaluation of mixing and dilution, travel times, direction of groundwater flow, and the possibility of denitrification occurring. Consideration may also need to be given to the construction of monitoring wells which can provide valuable information for the design of effluent irrigation.

The NWQMS document *Guidelines for Groundwater Protection* should be consulted when considering groundwater issues.

Surface waters

The following should be considered:

- general features - distances of various waterbodies from proposed plant, water uses and /or land application sites
- hydrological features - catchment area and drainage patterns.

Climatic conditions

Factors include the following, all of which affect evapotranspiration rates and any tendency to flooding or waterlogging:

- regional climate - rainfall, temperatures, humidity, winds, evaporation.
- local microclimate - diurnal pressure and associated air movement patterns.

Effluent should only be applied during conditions which will minimise polluted run-off, groundwater contamination or surface ponding.

Agricultural and horticultural practices

The decision to use either crops, trees or pasture, and the selection of species should take account of the fact that wool scour effluent is rich in nutrients and salts. Particular types of vegetation may accumulate nutrients more than others.

The vegetation which accumulates nutrients contained in the effluent needs to be harvested from the application site to prevent these nutrients being re-released into the soil (by decaying vegetation or as livestock wastes). Leaching of nutrients to groundwater is a particular concern, but can be controlled by careful design of effluent irrigation rates and attention to harvesting, and removing vegetation from the site. Where livestock are used to harvest the vegetation through grazing, the size of the reuse area will need to be increased to accommodate the nutrients returned in their manure. Operators should comply with appropriate health regulations and guidelines concerning human and animal consumption of irrigated crops.

If plant water requirements exceed the nutrient-limited effluent land treatment rate, the shortfall in water will need to be met from another source. Crops or pastures in wool scour effluent land treatment areas should ideally be dryland systems with the effluent providing the fertiliser requirements and a small amount of additional water.

4.4.2 Characteristics of the effluent

The characterisation of the effluent for a particular enterprise is fundamental to the operation and management of that enterprise and for the adequate assessment for any land application program. Collection of data by operators is encouraged and some or all of the following may be required for initial characterisation and ongoing monitoring:

- total solids
- suspended solids
- BOD
- COD
- organic carbon
- electrical conductivity (EC)
- exchangeable cations (sodium, magnesium, calcium)
- sodium adsorption ratio
- pH
- total Kjeldahl nitrogen
- ammonia nitrogen
- phosphorus
- potassium
- sulphate
- Methylene blue active substances (MBAS)
- oil and grease

Concentrations of nutrients, total dissolved solids or salinity, organic matter, BOD, and suspended solids (non-filterable residue) should be regularly tested in effluent and solid wastes/sludges. This is particularly important just prior to land application to calculate and determine appropriate application rates.

Biochemical Oxygen Demand (BOD)

Over-application of high BOD effluent can create anaerobic conditions in the soil. Prolonged oxygen depletion will reduce the soil micro-organisms' capability to break down the organic matter in the effluent and may ultimately lead to odours and surface and/or groundwater pollution.

It is therefore essential to apply effluent at rates that will not cause the development of anaerobic conditions. Resting periods between applications may be required to permit re-aeration of the soil. However, the quantity of oxygen which can be held in different types of soil varies according to soil texture and structure.

Total dissolved solids or salinity

The salinity or total dissolved solids (TDS) concentration of irrigation water, measured as electrical conductivity (EC) is an extremely important water quality consideration. especially since the salinity of wool scour effluent is high.

An increase in salinity causes an increase in the osmotic pressure of the soil solution, resulting in a reduced availability of water for plant consumption and possible retardation of plant growth. Recommended guidelines for salinity irrigation water are available in the NWQMS document *Australian Water Quality Guidelines for Fresh and Marine Waters* and cover a number of parameters including salts (TDS), sodium adsorption ratio (SAR). These guidelines also take into account soil characteristics, crop tolerance, climate, and irrigation practices which can influence soil loadings for particular contaminants.

With adequate drainage, salt accumulation in the soil can be controlled to an extent by the application rate of water. If the sum of applied irrigation water and rainfall is lower than evaporation and plant consumption, accumulation of salts in the main root zone will result. Proper irrigation management will allow application of sufficient excess water (leaching fraction) to move a portion of the salts out of the root zone, while not causing excessive increases in the groundwater table. (NWQMS - *Australian Water Quality Guidelines for Fresh and Marine Waters, p 5-7).*

Sites should not be irrigated with effluent if sub-surface drainage is likely to cause both rising groundwater tables and land salinisation in the direction of groundwater flow.

It is important to distinguish between salinity due to sodium chloride from that due to other dissolved solids, some of which may be beneficial to soil.

Salt management plan

A salt management plan that takes into account the issues discussed in the previous section, and which will consequently adequately manage salt in a land application program, should be developed. The decision to apply saline effluent will need to be dealt with on a case by case basis. Unless a detailed salt management plan can be developed to adequately manage the salt in a land application program, alternative methods of reuse/disposal of effluents from scours should be considered.

Sodium Adsorption Ratio (SAR)

Excessive sodium in irrigation water relative to calcium and magnesium can adversely affect soil structure and reduce the rate at which water moves into and through the soil. Problems of soil permeability increase when SAR approaches 10. (*Australian Water Quality Guidelines for Fresh and Marine Waters p5-5)*

Where possible application of wool scouring effluent to land with an SAR greater than 10 should be avoided to minimise the risk of soil waterlogging and destabilising soil structure. The SAR can be expressed as:

$$S.A.R = \frac{Na^{+}}{\sqrt{\dfrac{Ca^{++} + Mg^{++}}{2}}}$$

Na = sodium concentration (meq/L)
= (mg/L in effluent) / (22.99)

Ca = calcium concentration (meq/L)
= (mg/L in effluent) / (40.08 x 0.5)

Mg = magnesium concentration (meq/L)
= (mg/L in effluent) / (24.32 x 0.5)

Where effluent with a high SAR poses a problem, it could be blended with better quality water. Dilution of effluent streams with high quality water is not recommended practice in areas where water resources are scarce. Evaporative disposal may be an alternative worth considering. Alternating irrigation with high quality water is not recommended unless soil amelioration is also made. Alternating low salinity water after using high salinity water must be monitored to avoid crusting and sealing which can lead to an appreciably reduced infiltration rate. As with all other parameters in the design of a land irrigation system, the actual suitable SAR of the effluent will depend on the soil characteristics of the site. Sodium is required in limited amounts for most plant growth. However, some plants are sodium-sensitive and can be affected by low concentrations of exchangeable sodium. It has been reported that sodium toxicity can occur in sensitive fruit crops when SAR is as low as 5.5 (Bernstien (1962) p5-6 NWQMS - *Australian Water Quality Guidelines for Fresh and Marine Waters).*

Potassium

High potassium levels in the effluent means that soil potassium levels need to be considered and regularly monitored. Further irrigation or dilution with clean water may be necessary to prevent salinisation of the soil. Wool scour effluent may be considered a valuable resource in potassium-deficient areas. Consideration could be given where possible to recovery through evaporation for use in intensive agriculture. If potassium is to be used as a soil nutrient, it may be desirable to avoid contaminating it with sodium (eg from sodium salts used as builders).

Effluent from carbonising treatments contains sodium sulphate. In inland scouring locations, long term application of large amounts of sodium sulphate to land is not acceptable, and carbonising should be limited to sites where the sodium sulphate load can be handled without adverse effect.

Nutrients

The nutrients in effluent most likely to be utilised by plants are nitrogen, phosphorus and potassium. The availability of these nutrients for plant uptake is spread over a number years. Nitrogen, for example is present as ammonium, ammonia, organic nitrogen, nitrate and nitrite, however plants only take up nitrogen in the ammonium and nitrate forms from the soil. The other forms can become available through the processes of the nitrogen cycle so that for example the organic nitrogen (proteins) is slowly mineralised into plant available forms over a number of years. Phosphorus is also released for plant uptake over time although some of it is quickly bound up by the soil and not available for plant use.

Optimum use of nutrients will depend on soil type, moisture availability, crop type and land management.

4.4.3 Irrigation Management

An irrigation management plan should be developed detailing the following:

- irrigation methods
- crop, water and nutrient requirements
- application rates
- scheduling
- design for the collection
- storage
- utilisation and management of stormwater and tailwater
- a salt management plan.

The intensity and depth of irrigation should be adapted to the soil and vegetation to prevent excessive leaching of effluent beneath the root zone. This can be determined by appropriate monitoring of soil moisture and salinity profiles.

Caution should be exercised when spraying effluent, as it may contain micro-organisms and pathogens and can drift from the site. Aerosols which result from spraying should be contained on site and surrounded by a non irrigated vegetation buffer zone. Local authorities should be consulted when determining the size of the buffer zone. Operators should take care that they do not inhale aerosols, and should comply with appropriate health regulations and guidelines concerning human and animal consumption of irrigated crops.

An irrigation system should take into account the drainage characteristics of the soils. Better drained soils would enable removal of salt and prevent long-term accumulation around the root zones.

Applications should be scheduled based on a water deficit. When the soil is saturated in periods where rainfall exceeds evaporation, irrigation waters will need to be stored until the soil is suitable for irrigation.

Adequate storage will be required to retain effluent during wet periods or seasons. A generally accepted standard is to design any system to cope with the wettest year in ten. Hydrological expertise should be engaged to design this capacity and to provide guidance on local constraints on effluent irrigation.

Other nutrient-intensive activities incompatible with environmental objectives (such as animal holding) should be excluded from irrigated areas.

It is important that properly trained personnel are available on site to manage the irrigation.

Control of stormwater and irrigation tailwater

Upslope stormwater should be diverted to prevent it from entering the solid and effluent utilisation areas. Runoff from the solid wastes/sludge and effluent utilisation areas should be managed to minimise discharge to waters by the use of buffers zones, terminal ponds etc. If irrigation runoff occurs, it should be contained.

Wastewater irrigation may yield a tailwater discharge which will ultimately need to be disposed of in an environmentally sensitive way. Management of tailwater must be a key consideration of every wastewater irrigation project, as it is often this issue which provides a major impediment to the sustainability of wastewater irrigation.

Performance assessment options

These include:

- the proportion of treated effluent used for land application such as for irrigating crops, pastures or trees is monitored and recorded
- surface and groundwater is monitored for ambient levels of salt, BOD, nitrogen, phosphorus, potassium, pH, and carbon (refer to recommended levels for environmental values in *Australian Water Quality Guidelines for Fresh and Marine Waters* as a guide)
- all polluted runoff has been contained
- soils are monitored for the effect of effluent application, including physical, chemical and biological characteristics
- the effects on public amenity are evaluated by observing buffer zones and noting any public complaints
- crops, trees or pasture are monitored by observing yield and foliar symptoms, growth rates and health
- records are maintained from which the history of loading of water nutrients, salts and contaminants can be calculated for all areas where effluent is applied.

4.5 Use of solid wastes and sludge

Objective

To make effective and environmentally beneficial use of wool scouring solid waste and sludge. Before and during land application, the scheduling regime and application rates of the solid waste/sludge need to be considered. As for wool scour effluents, the issues discussed in

Sections 4.4.1 and 4.4.2 also need to be considered when applying solid wastes or sludges to land.

Guidelines

Coarse soil separated from the wool scour effluent should desirably be returned to land. It should be removed early in the waste stream to reduce the load on later utilisation or treatment steps. Even in country scours, there are advantages in using efficient soil recovery procedures to minimise silting of lagoon systems. However these solids will also contain grease and wax that is not readily biodegradable, and which may lead to odour problems. Where the organic load is high (2 percent or more), pre-treatment (composting) to degrade the residual grease and wax may be necessary before land application. Where land application is not feasible, it should be disposed of in secure landfills.

While solid wastes such as waste fibre and vegetable matter from the wool scouring process may not be large in weight, they can introduce unwanted weed varieties, particularly if unsterilised.

4.5.1 Characteristics of sludge

Sludge will generally derive from:

- the processing stream
- occasional desilting of settlement lagoons.

Sludges from these sources will have different characteristics and some (eg with remaining wool wax) may require treatment before application to land.

Lagoons should be desludged once the sludge volume takes up one third of total volume (or half depth) of the lagoon. This typically represents 5 to 7 years and 10 to 12 years use for primary lagoons receiving unscreened and screened effluent respectively. Secondary lagoons rarely need desludging. If a spare lagoon is available, the most efficient means of sludge removal is surface water decanting and solar drying. Sufficient sludge should be retained in the lagoon after desludging to enable its activity to be rapidly regained upon recommissioning.

Professional advice should be sought on both sludge removal from the lagoon and application rates to soil (based on tests of that particular sludge). Nutrient loading should take account of any effluent application rates if these overlap.

The effect of applying all solids to land needs to be considered in the Environmental Management System. Storage areas for solids should be bunded and have adequate drainage. If not adequately treated, stored solids can produce significant odour and attract flies and rodents. They should not be allowed to become anaerobic.

Accurate assessment of the characteristics of sludge should be undertaken, before and after treatment, if applicable, to determine suitability for land application.

4.5.2 Land spreading of sludge

The amount of land required to sustainably accept sludge will depend on similar factors to those considered for the disposal of effluent. Soils receiving sludges or sludge will be affected mainly at the surface, unless very large quantities are applied or unless irrigation is also undertaken. In dryland conditions incorporation of sludge into the topsoil is unlikely to lead to rapid changes in subsoil properties. If irrigated crops are grown however, leaching of soluble material from the waste is accelerated and subsoils will require regular monitoring, particularly for nitrogen movement, salinity and sodicity.

Performance assessment options

These include:

- the output of sludge from the wool scour is measured and amounts being utilised recorded to gauge effectiveness of program
- characteristics of sludge are monitored to determine suitability for use
- soil chemical and physical condition is monitored to determine environmental effect due to land spreading.

4.6 Alternative options for wool scour effluent

Objective

To dispose of wool scour effluent in an environmentally acceptable manner, only when effective use of the effluent is not feasible.

Guidelines

No effluent should be discharged to surface or groundwaters unless it is consistent with the integrated catchment management strategy of the area, and the relevant guidelines of the licensing agency. Ambient water quality immediately downstream of the wool scour plant should remain comfortably within the environmental value attributed to the receiving water body. This may require tertiary treatment (viz. nutrient removal, filtration and disinfection) of the effluent prior to discharge. Environmental values of water and the related ambient water quality parameters are described in the NWQMS document *Australian Water Quality Guidelines for Fresh and Marine Waters* which provides further information on this topic.

Where salinity is a problem, highly saline effluents should be separated where possible and directed to evaporating basins for collection of the salts. Any discharge to the sewerage system will need to comply with the requirements of the State, Territory and local government authorities. Additional information on the management of industrial effluent is contained in the NWQMS document *Sewerage Systems - Acceptance of Trade Waste.*

Performance assessment options

These include:

- the effluent quality of any discharge is monitored
- the environmental values of relevant water bodies are monitored
- if discharge to sewer is permitted, the requirements of the relevant authority are monitored to ensure they are being achieved
- compliance with both a regional catchment plan and the relevant guidelines of the licensing agency or agriculture department regarding effluent disposal, including by sewer
- regular assessment of soil condition, surface water, groundwater and odour
- minimisation of unacceptable off-site impacts on water, land, air or vegetation.

4.7 Monitoring and reporting

Monitoring is an essential part of any Environmental Management System and/or Plan. The extent of monitoring required should be determined on the basis of wool scour and property size, and the environmental sensitivity of the location. Monitoring of effluent quality and volumes discharged at land treatment areas is needed to effectively manage an effluent land treatment system. Monitoring of groundwater levels and quality, and soil water concentrations below rooting depths is essential.

Objectives

To ensure the plant's on-going efficient operation and for regulatory purposes. To ensure the plant is meeting its Environmental Management System and/or Plan.

Guidelines

- Include monitoring and reporting on the plant's performance, including the effluent management system.
- Maintain records of monitoring data to be made available for review by relevant authorities on request.
- Review procedures and data periodically with regulatory authorities to ascertain the data's usefulness and to effectively monitor performance.
- Develop a Quality Assurance System and use accredited methods and laboratories for the analysis of samples to ensure the integrity of monitoring data (eg NATA accredited).
- Regularly inspect facilities, in particular pumps and waste storage reservoirs.
- Undertake regular monitoring of land to which effluent has been applied. The soil should be monitored for nutrient levels, particularly: potassium, available phosphorus, total Kjeldahl nitrogen, nitrate and ammonium as well as salt levels. Visual assessment should be made for waterlogging, sealing, erosion etc. Harvested crops should also be sampled and analysed to monitor nutrient removal from the site.
- Regularly monitor surfacer waters liable to be affected by a wool scour. Groundwater may be monitored depending on the sensitivity of the site to groundwater.
- Supplement regular reporting with "exception" reporting to alert supervisors to unusual variations in plant performance .
- Pollution events should be reported to relevant regulatory authorities.
- Provide plant managers with up-to-date information on their plant's environmental performance to enable problems to be detected early and remedial action implemented.
- Provide operators with adequate education and training, particularly in total quality management procedures, and risk management techniques, to assist in ensuring compliance with environmental regulations and requirements
- Analysis of certain characteristics of the effluent may be required for initial characterisation and ongoing monitoring

Relevant State/Territory and/or local authorities may require occasional or regular reporting depending on the site sensitivity or license arrangements. . Establishments with a history of consistently poor environmental performance may be required to submit reports on their environmental performance more frequently.

Performance assessment options

These include:

- adequate operational planning, consultation, recording, monitoring, reporting, and education and training of staff
- consistent adherence to licence conditions
- no environment related complaints
- regular reporting to management and staff, including feedback on performance, changes to the system, and an internal audit system with relevant documentation and reporting.

4.8 Contingency measures

Objective

As part of a good overall strategic plan for the plant, to have in place effective procedures enabling plant managers to effectively respond to all emergencies and contingencies.

Guidelines

Wool scours should be prepared for:

- disruption to power supplies which may affect the plant's effluent management system
- extreme rainfall events
- disruption to wool scour operation or treatment by storms, flooding, fire, etc;
- plant breakdowns
- plant spillages
- clean up of site contamination (eg soil removal or treatment)
- changes in the physico-chemical environment which can disrupt the effectiveness of the effluent treatment system's biological activity
- overloading of aerobic treatment plants or lagoons, or unusually low effluent inputs which can affect the system's biological treatment activity
- accidental discharge of hazardous materials into the effluent stream
- changes in the physico-chemical environment which can disrupt the effectiveness of the system's biological activity
- temporary or permanent loss of access to effluent application and disposal facilities
- temporary or permanent loss of trained operators. All managers and staff should be aware of the plan and their individual responsibilities during emergencies. The plan should be regularly rehearsed and updated

Performance assessment options

- An up-to-date contingency plan is disseminated to staff and regularly inspected and trialed.
- Record and regularly analyse the operations response to specific contingencies which have arisen.

APPENDICES

Appendix A : The National Water Quality Management Strategy (NWQMS)

The Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) are working together to develop a National Water Quality Management Strategy (NWQMS).

The guiding principles for the National Water Quality Management Strategy are set out in *Policies and Principles - A Reference Document*, which emphasises the importance of:

- ecologically sustainable development
- integrated (or total) catchment management
- best management practices, including the use of acceptable modern technology, and waste minimisation and utilisation
- the role of economic measures, including user pays and polluter pays.

The process of implementing the National Water Quality Management Strategy involves the community working in concert with government in setting and achieving local environmental values, which are designed to maintain good water quality and to progressively improve poor water quality. It involves development of a plan for each catchment and aquifer, which takes account of all existing and proposed activities and developments, and which contains the agreed environmental values and feasible management options.

Figure A1 outlines principles, a process and outcomes of the NWQMS.

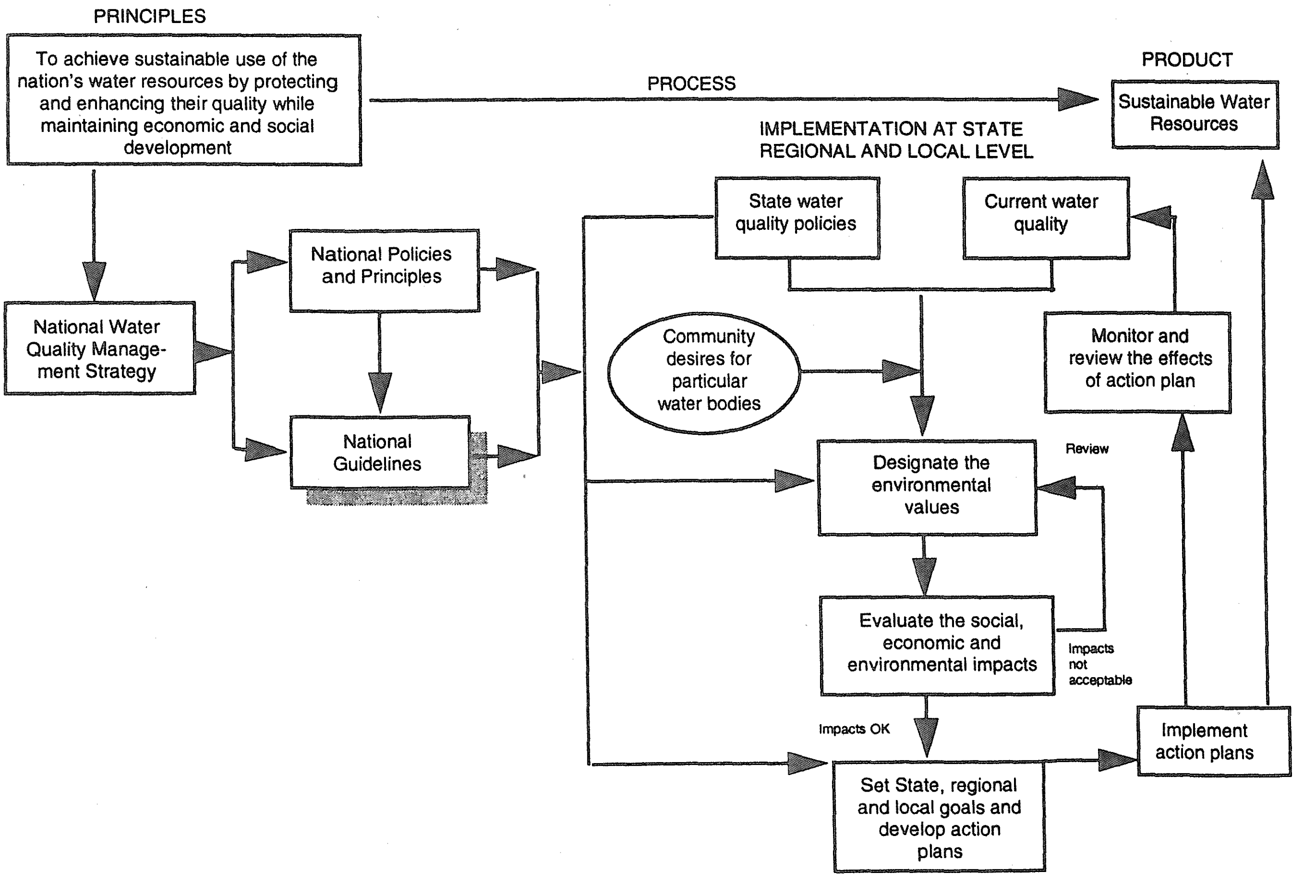

Figure A1 National Water Quality Management Strategy

BOX 1 DOCUMENTS OF THE NATIONAL WATER QUALITY MANAGEMENT STRATEGY

Paper No.	Title
Policies and Process for Water Quality Management	
1	Water Quality Management - An Outline of the Policies
2	Policies and Principles - A Reference Document
3	Implementation Guidelines
Water Quality Benchmarks	
4	Australian Water Quality Guidelines for Fresh and Marine Waters
5	Australian Drinking Water Guidelines - Summary
6	Australian Drinking Water Guidelines
7	Guidelines for Water Quality Monitoring and Reporting
Groundwater Management	
8	Guidelines for Groundwater Protection
Guidelines for Diffuse and Point Sources	
9.	Rural Land Uses and Water Quality
10.	Guidelines for Urban Stormwater Management
11.	Guidelines for Sewerage Systems - Effluent Management
12.	Guidelines for Sewerage Systems - Acceptance of Trade Waste (Industrial Waste)
13.	Guidelines for Sewerage Systems - Sludge (Biosolids) Management
14.	Guidelines for Sewerage Systems - Use of Reclaimed Water
15.	Guidelines for Sewerage Systems - Sewerage System Overflows
16a	Effluent Management Guidelines for Dairy Sheds in Australia
16b	Effluent Management Guidelines for Dairy Processing Plants in Australia
17.	Effluent Management Guidelines for Intensive Piggeries in Australia
18.	Effluent Management Guidelines for Aqueous Wool Scouring and Carbonising in Australia
19.	Effluent Management Guidelines for Tanning and Related Industries in Australia
20.	Effluent Management Guidelines for Australian Wineries and Distilleries

The guidelines for diffuse and point sources are national guidelines which aim to ensure high levels of environmental protection that are broadly consistent across Australia.

Appendix B: Outline of aqueous wool scouring and carbonising processes

The aqueous process is a multi-stage extraction process in which the wool is passed continuously through a series of bowls containing scouring liquor. Squeeze presses are used between bowls to remove solution and contaminants from the wool. The efficiency of these presses in solution removal is important in determining the amount of water used and energy required to dry the wet wool emerging from the final squeeze press before the dryer.

The process of aqueous scouring has changed significantly over the past 40 years with the introduction of synthetic detergents, use of improved wax and soil recovery systems and improved effluent handling. Most of the raw wool scoured throughout the world is scoured in aqueous systems using rake and/or harrow machines.

A range of downstream processing operations can be conducted on the cleaned wool after scouring, such as dyeing, bleaching, insect proofing and shrink proofing. Management of effluents from these processes is not included in these Guidelines as they are quite separate operations. Carbonising (removing vegetable matter from wool using sulphuric acid) is used on wool with very high levels of vegetable contamination, usually as an in-line continuation of the scouring process. The acid rinsed from the fibre in the washing stage must be neutralised before discharge. The effluents from carbonising treatments will therefore contain neutralised sulphuric acid residues, usually as sodium sulphate, as well as residues from bleaching agents if they are used. Management of carbonising effluents is included in these Guidelines.

Non-ionic detergents are mostly used, either in neutral conditions or with sodium carbonate to increase the rate of removal of the wax in the scouring bowls. Care must be taken not to damage the wool under these more alkaline conditions. The two main types of detergents are nonyl or octylphenol ethoxylates and fatty alcohol ethoxylates. Both are biodegradable, but attention may need to be given to build-up of degradation products from the alkyphenol ethoxylate type. It is only at very low temperatures (appropriate to European conditions) that the alkylphenol types are slower to degrade.

Best scouring is obtained with soft water, that is with total hardness less than 70 mg $CaCO_3$/L equivalent. If the hardness is greater than 100 mg/L, a softening plant needs to be installed, or sequestering agents (agents which bind ions so they cannot react) may be used in the scour. However, sequestering agents may cause significant problems with effluent disposal.

In modern scour lines, soil is removed from the scour solution by soil recovery devices, such as hydrocyclones. However, only about 45 per cent of the soil can be recovered this way, the rest remaining in the scour effluent. The wool wax is removed by centrifuging as a dilute cream. Anhydrous wool wax (grease) can be obtained by mixing it with a small volume of near-boiling water and recentrifuging.

A common problem is that certain processes will generate wax rich sludges, and attention must be given to their disposal or preferably to their beneficial re-use. One approach is to concentrate the scour solution by evaporation, the condensate is recycled, and the soil and wax may be burned for fuel. These processes are capital intensive and expensive to operate. Another is to compost the sludge after adding substrates such as sawdust or straw. Where the ultimate discharge of treated liquor is to ocean, potassium is not an issue, but it is still useful to consider reuse of potassium that can be recovered from the suint bowl (see section on

Utilisation). Potassium concentration is a useful tracer when checking for scour impacts on the environment.

Correct levels of time of immersion in the scour, scour temperature, and mechanical action are all important in maintaining wool quality, securing efficient scouring and minimising the quantities of water and other materials used.

The wool is dried after it has passed through the scour. Various types of dryers may be used, and dust removal is important at this stage.

New scouring sets should incorporate optimised systems for continuous removal of contaminants and a constant flowdown of scour effluent from the plant. Most should also have integral wax plants with recycling facilities. Sophisticated monitoring and control equipment, much of it computerised, should be a part of the new sets. Scouring would therefore be carried out under equilibrium conditions and in a continuous manner.

An outline of wool scouring and carbonising processes is at Figure B1.

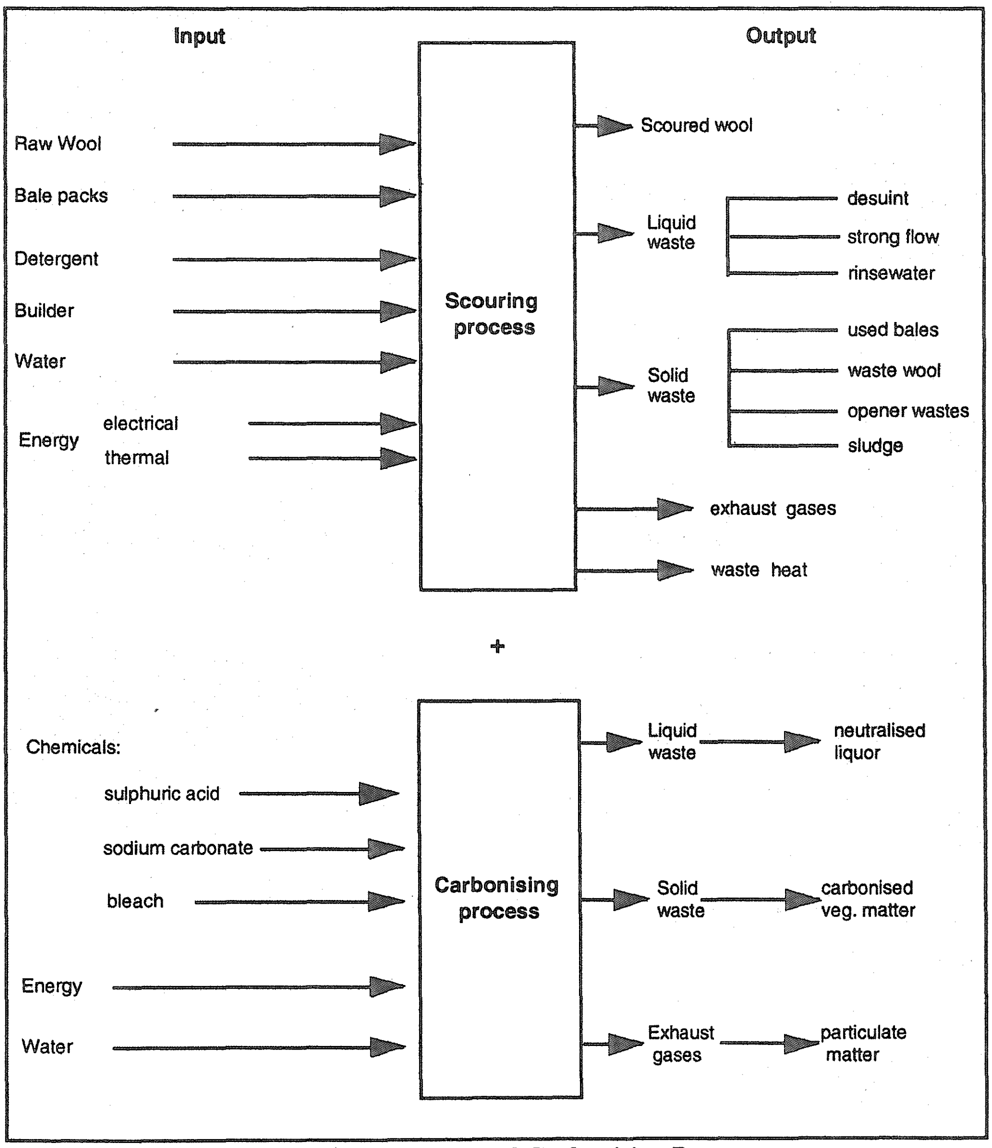

Figure B1 An Outline of Wools Scouring and Carbonising Processes

Appendix C: Further information

Further Reading

(The NWQMS documents listed in Box 1 in the preamble to these Guidelines should also be consulted)

Bateup, B O Optimisation of the Aqueous Scouring Process, CSIRO Division of Wool Technology

Bateup, B O, Scouring Effluent Treatment, Proceedings of seminar 'Adding Value to Australian Wool' March 1992, CSIRO Division of Wool Technology

Bateup, B O, Christoe, J R, and Russell, I M, CSIRO Division of Wool Technology, *Scouring Wastes: A Resource, Not a Problem*, Proceedings of the Ninth International Wool Textile Research Conference, 28 June -0 5 July, 1995, Biella, Italy.

Christoe, J R, Comparative Scouring Systems, CSIRO Division of Wool Technology

Christoe, J R, Waste Water Treatment and Disposal, Wool Scouring and Worsted Carding: New Approaches. Symposium held by CSIRO Division of Wool Technology November 1986.

Department of Industry, Technology and Commerce, Environmental Technology Committee, (1992a): *Aqueous wool waste workshop.* Research Report No. 1, AGPS, Canberra.

Environment Protection Authority NSW (1995): *The Utilisation of Treated Effluent by Irrigation*

Environment Protection Authority (Victoria) (1992), *Guidelines for Wastewater Irrigation,* EPA Publication no 168

Standards Australia 1995, *Environmental management systems - Specification with guidance for use.* Interim Australian/New Zealand Standard AS/NZ ISO 14001 (Int):1995, Standards Australia, Sydney

Standards Australia 1995, *Environmental management systems - General guidelines on principles, systems and supporting techniques.* Interim Australian/New Zealand Standard AS/NZ ISO 14004 (Int):1995, Standards Australia, Sydney

Wool Industry Review Committee Report: *Wool - Structuring for global realities.* AGPS, Canberra, August 1993

Wool Processing Task force, (1993): *Maximising the return: Adding value to Australian wool,* AGPS, Canberra.

Appendix D: Sources of further advice

CSIRO Division of Wool Technology

CSIRO Division of Water Resources (DWR)

Industry Consultants

Local Government Authorities

Regional Colleges

State Departments of Agriculture or Primary Industries

State Departments of Conservation and Land Management

State Environment Protection Authorities

State Water Authorities

Appendix E: Glossary

Aerobic	a process where dissolved or free oxygen is present.
Anaerobic	a process or condition where there is no dissolved or free oxygen.
Aquifer	a layer of rock which holds water and allows water to percolate through it.
Biochemical Oxygen Demand (BOD):	the amount of oxygen required by aerobic organisms to carry out oxidative metabolism in water containing organic matter. It is determined by measuring the amount of oxygen gas absorbed during a particular laboratory analytical test (BOD test), in which components of a water sample are broken down by aerobic micro-organisms under specified conditions during a stated number of days. BOD_5 denotes a 5-day BOD.
Builders	chemicals, usually inorganic salts, that have no detergent action in their own right, but enhance the performance of the detergent. Sodium carbonate is the most common agent.
Catchment area	a drainage area, especially of a reservoir or river.
Chemical Oxygen Demand (COD):	a measure of the quantity of oxidisable (combinable with oxygen) components present in water. It is determined by measuring the amount of oxygen gas absorbed during a particular laboratory analytical test (COD test), in which components of a water sample are broken down by an inorganic chemical (an oxidising agent) under specified conditions during a certain number of hours.
Denitrification	removal of nitrogen.
Effluent	liquid and associated solid waste at all stages from production to utilisation or disposal.
Electrical conductivity	measure of salinity in water.
Environmental Management System	provides the management, administrative and monitoring framework which ensures that an organisations environmental risk is minimised and that its environmental policy together with associated objectives and targets are achieved. Stages in an EMS, based on the ISO 14000 series comprise commitment to a policy, planning which includes

evaluation of relevant regulatory framework, setting objectives and targets, establishing a management program (EMP), definition of personnel and responsibilities, identifying training needs, establishing and maintaining EMS documentation, emergency and preparedness and response procedures and establishing operational controls, and carrying out audits and reviews including monitoring and review.

Environmental values — particular values or uses of the environment that are conducive to public benefit, welfare, safety or health and that require protection from the effects of pollution, waste discharges and deposits. Several environmental values may be designated for a specific water body. They are often called beneficial uses in the water quality literature. Five environmental values are:

- agricultural water
- drinking water
- ecosystem protection
- industrial water
- recreation and aesthetics

Refer to the NWQMS documents Policies and Principles - A Reference Document, and Australian Water Quality Guidelines for Fresh and Marine Waters.

Evapotranspiration — Water lost from soil by evaporation and/or plant transpiration.

Exchangeable Sodium Percentage (ESP) — the amount of exchangeable sodium as a percentage of the cation exchange capacity. It is a measure of the sodicity of the soil. Sodicity relates to the likely dispersion on wetting and shrink/swell properties.

Facultative — a condition where both the aerobic and anaerobic conditions occur. The surface of a lagoon may be aerobic and the bottom anaerobic. The term also refers to micro-organisms that can survive and reproduce under both aerobic and anaerobic conditions.

Guideline — provides guidance on possible means of meeting desired environmental outcomes. Guidelines are not mandatory.

Hydraulic loading — volume of water applied to an area of land.

Infiltration rate — rate of entry of water into the soil.

Katabatic drainage/wind	a wind caused by cold air flowing downhill. When a sloping land surface cools by night time radiation, the cold air in contact with the ground flows downhill and along the valley bottom.
Leaching	the downward movement of a material in solution through soil.
Leaching fraction	the leaching fraction of soils refers to the ratio of deep drainage to the depth of rainfall plus irrigation over the same time period. The smaller the leaching fraction, the larger the water salt concentration within the root zone, or the higher the salt concentration experienced by plant roots.
Noils	short broken bits of wool fibre that are removed at the combing stage in topmaking, maybe 7% of the total scoured weight. Noils usually go into production of woollens.
Perched watertable	upper surface of a zone of saturation where an impermeable stratum causes groundwater to accumulate above it over a limited lateral extent. It is situated above the main watertable.
Phosphate sorption capacity	a measure of the inherent ability of soil particles to adsorb phosphorus from the soil solution.
Risk management	is a decision-making process that entails considerations of political, social, economic and engineering information together with risk-related information to develop, analyse and compare regulatory options and to select the appropriate regulatory response to a potential health or environmental hazard. The entire risk management process consists of eight steps. These are hazard identification, exposure assessment, effects assessment, risk characterisation, risk classification, risk benefit analysis, risk reduction, monitoring.
Standard	a standard is a quantifiable characteristic of the environment against which environmental quality is assessed. Standards are mandatory.
Suint	that portion of the sheep's fleece which is soluble in cold water after the wax has been removed. It is a complex mixture of metallic ions, organic acids, peptides, weak bases, neutral substances, and inorganic cations. Potassium salts of organic acids are a large component of suint. In Australian merino fleece, the amount of suint ranges from 2 to 13% with an average of 6.1%.

Tailwater	runoff from irrigation areas which contains nutrients and salts. Also first flush rainfall runoff from land used for wastewater disposal.
Total dissolved solids (TDS)	the amount of dissolved solids in waste water.
Total Kjeldahl nitrogen (TKN)	is a determination of organic nitrogen and ammonia
Total solids (TS)	the sum of dissolved and undissolved solids in water or waste water, usually expressed in milligrams per litre.
Total suspended solids (TSS)	the amount of volatile and fixed suspended solids in waste water.
Watertable	the level below which the pore space between sediments and fractures in rock are saturated with water. In an unconfined aquifer, the watertable is the level of the water standing in a well.