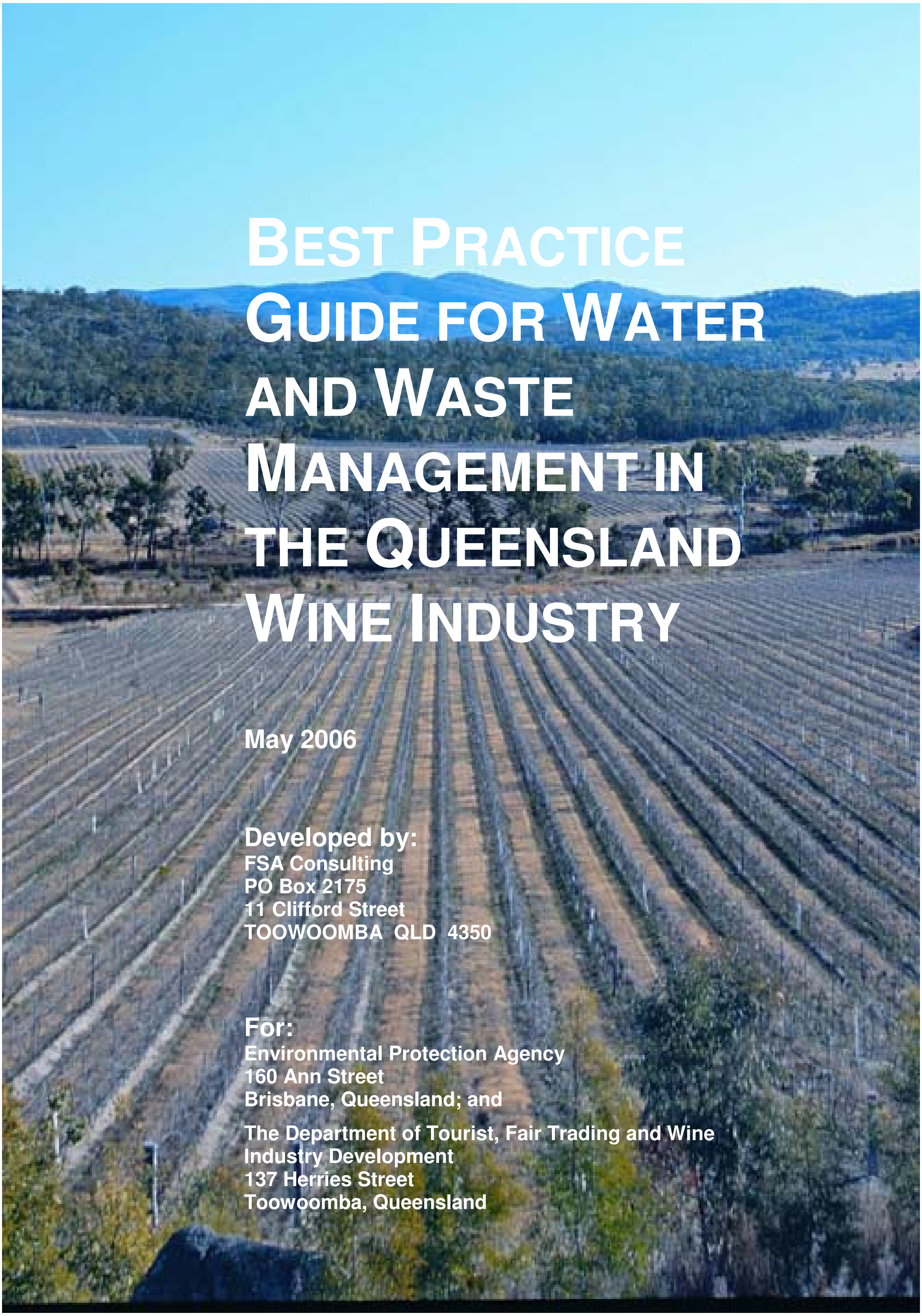


Best Practice Guide for Water and Waste Management in the Queensland Wine Industry

May 2006

Developed by:
FSA Consulting
PO Box 2175
11 Clifford Street
TOOWOOMBA QLD 4350

For:
Environmental Protection Agency
160 Ann Street
Brisbane, Queensland; and

The Department of Tourist, Fair Trading and Wine Industry Development
137 Herries Street
Toowoomba, Queensland

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 PURPOSE OF THIS DOCUMENT

The Department of Tourism, Fair Trading and Wine Industry Development is working in partnership with the Queensland wine industry, other Queensland Government Departments, relevant Commonwealth agencies/organisations and interested industry stakeholders to:

- support the growth of the Queensland wine industry;
- implement the Wine Industry Development Strategy;
- market and promote Queensland wine;
- coordinate Government resources focusing on wine; and
- promote Queensland wine interstate, nationally and overseas.

The Wine Industry Development Strategy covers the three stages of the wine industry process chain, including:

- viticulture;
- wine production; and
- marketing and distribution.

This strategy supports the actions of all levels of government, industry and stakeholders with a role in the development of the Queensland wine industry. In recognition of the importance of gaining a comprehensive view of the industry, its issues and opportunities, a consultation program involving a series of industry forums and information gathering workshops in regional locations and Brisbane was held. The outcomes of the workshops provided the basis for the Wine Industry Development Strategy.

This guide has been developed to address Issue 3 of Strategy B: Wine Production Development, which is:

> ***"Develop, in co-operation with industry, guidelines on best practice in relation to water use in production and waste disposal under the Environmental Protection Act 1994".***

This component of Strategy B is being developed by the Environmental Protection Agency (EPA), the Department of Tourism, Fair Trading and Wine Industry Development (DTFTWID) and peak industry bodies.

This guide contains information regarding:

- overview of the Queensland wine industry;
- relevant environment legislation;
- potential environmental impacts of wine production;
- wine production processes and waste production;
- waste treatment and storage;
- waste utilisation or disposal, including irrigation practices;
- eco-efficiency measures in wine production;
- environmental monitoring; and
- environmental management systems (EMS).

2 OVERVIEW OF THE QUEENSLAND WINE INDUSTRY

The Queensland wine industry comprises mostly small family-owned wineries, with a number of well-established, mid-size wineries and several larger commercial producers.

The industry has grown significantly in recent years and now has around 200 vineyards, covering about 1200 ha. Most of this growth has occurred in the past seven years, with significant plantings throughout the southeast corner of the State (Table 1).

TABLE 1 - DISTRIBUTION (AREA) OF WINE GRAPES IN QUEENSLAND)

Region	Area (Ha)
Granite Belt	520
South Burnett	400
Darling Downs	100
Gold Coast and Hinterland	50
North Burnett	40
Sunshine Coast and Hinterland	20
Scenic Rim and Brisbane and Somerset Valley and D'Aguilar Ranges	20
Western Downs (including Maronoa)	20
Inglewood District (not listed as a wine region as there are no cellar doors)	30
Total	1200

Source: Queensland Wine Industry Development Strategy – DTFT&WID (2004) and recent updated survey data

The number of Queensland wine producers has grown to over 160 and there are eight wine merchants. The distribution of wine producers by region is in Table 2.

TABLE 2 - DISTRIBUTION OF WINE PRODUCERS IN QUEENSLAND

Region	No.
Granite Belt	70
South Burnett	16
Darling Downs	12
Gold Coast and Hinterland	15
North Burnett	11
Sunshine Coast and Hinterland	17
Scenic Rim and Brisbane and Somerset Valley and D'Aguilar Ranges	20
Western Downs (including Maronoa)	4
Total	**165**

Source: Queensland Wine Industry Development Strategy – DTFT&WID (2004) and recent updated survey data

The annual grape crush has increased from less than 500 tonnes in 1998, to over 5000 tonnes in 2005. Production is now approximately 2.7 million litres per annum (DTFT&WID, 2004).

3 LEGISLATION

3.1 Environmental Protection Act

The object of the *Environmental Protection Act* 1994 (EP Act) and the associated *Environmental Protection Regulation 1998* is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. This is known as 'ecologically sustainable development'.

In seeking to protect Queensland's environment, the EP Act and the associated regulation place a responsibility on all Queenslanders to exercise a 'general environmental duty'. That is:

> ***'A person must not carry out any activity that causes or is likely to cause environmental harm unless they take all reasonable and practicable measures to prevent or minimise the harm.'***

In deciding what are reasonable and practicable measures, the following need to be considered:

1. The nature of the harm or potential harm.
2. The sensitivity of the receiving environment.
3. The current state of technical knowledge for the activity.
4. The likelihood of successful application of the different measures that might be taken.
5. The financial implications of different measures as they would relate to the type of activity.

Along with the EP Act and the *Environmental Protection Regulation 1998*, there are a number of Environmental Protection Policies (EPPs), namely:

- *Environmental Protection (Air) Policy 1997* (EPP Air).
- *Environmental Protection (Noise) Policy 1997* (EPP Noise).
- *Environmental Protection (Water) Policy 1997* (EPP Water).
- *Environmental Protection (Waste Management) Policy 2000* (EPP Waste).

3.2 Environmentally Relevant Activities

An Environmentally Relevant Activity (ERA) is one in which:

1. A contaminant will be or may be released into the environment when the activity is carried out.
2. The release of the contaminant will cause or may cause environmental harm.

An ERA requires a development application and registration to operate lawfully under the EP Act. The fees payable for these approvals depend upon the level of risk of environmental harm from the activity. There are two levels of ERA, Level 1 is considered to present a higher risk to the environment and an annual fee is payable. Level 2 ERAs are considered to present a lower risk to the environment than level 1 ERAs and there are no ongoing fees.

One exception to this rule is if the activity is considered to have 'deemed approval' i.e. it was operating before 1995 and there has not been any change in owner or expansion of the activity. In this instance only a registration is required at present.

Wineries are considered a Level 1 ERA (29b Food processing – Beverage Production) if their production capacity exceeds 400,000 litres per year. An enterprise may also be considered a Level 1 ERA if they operate a standard sewage treatment works (ERA 15 – Sewage Treatment) having a peak design capacity of 21 or more equivalent persons.

ERAs will have site specific recording and reporting requirements to the Responsible Authority. The Responsible Authority for Food processing – Beverage Production (ERA 29b) and Sewage Treatment (ERA 15) is the Environmental Protection Agency.

3.3 Vegetation Management Act 1999

The purposes of the *Vegetation Management Act 1999* are to regulate the clearing of vegetation on freehold land to:

(a) Preserve the following:

  (i) Remnant "endangered" regional ecosystems.

  (ii) Remnant "of concern" regional ecosystems.

  (iii) Vegetation in areas of high nature conservation value and areas vulnerable to land degradation.

(b) Ensure that the clearing does not cause land degradation.

(c) Maintain or increase biodiversity.

(d) Maintain ecological processes.

(e) Allow for ecologically sustainable land use.

Along with the *Vegetation Management Act 1999*, there is the *Vegetation Management Regulation 2000.*

When considering undertaking any clearing of native vegetation, ensure that it will not contravene the requirements of the *Vegetation Management Act 1999* and associated regulations.

3.4 Water Act 2000

A primary purpose of the *Water Act 2000* is to advance the sustainable management and efficient use of water and other resources in Queensland by establishing a system for the planning, allocation and use of water. Along with the *Water Act 2000*, there is the *Water Regulation 2000.*

Water allocations often need to be licensed. In most circumstances a licence will be needed to draw water from a bore or from surface water. There may also be restrictions on how much runoff water can be harvested from a property.

3.5 National Pollutant Inventory

Estimations of emissions may be required to be reported for the National Pollutant Inventory (NPI). NPI reporting is required under the *Environment Protection Regulation* (1998), and estimates of emissions of NPI-listed substances to air, water and land **must** be reported for each substance emitted at above threshold levels. (The full list of 90 reportable substances can be seen on the NPI web site: www.npi.gov.au/about/list_of_subst.html).

The full list must be considered when determining if thresholds are being exceeded. NPI reporting of pollutant emissions is required annually by 30 September for financial year reporters. (Calendar year reporting can be negotiated). Greenhouse gases and ozone depleting substances are currently not reported to the NPI.

The Emission Estimation Technique Manual for Wine and Spirit Manufacturing (Department of Environment and Heritage, 2005) has been developed to advise on what a winery is required to provide or retain for NPI reporting purposes, including emission estimation techniques. This manual is available from the NPI website at: www.npi.gov.au. A summary of this is included below.

3.5.1 Emissions to Air

Emissions to air can be fugitive and point source. A list of possible emissions to air is included in Table 3.

TABLE 3 - LIKELY AIR EMISSIONS OF NPI-LISTED SUBSTANCES FROM WINE MANUFACTURING

Emission Source	Possible Emissions
Fermentation	○ Ethanol (largest emission by volume) ○ Acetaldehyde ○ Methanol ○ Hydrogen sulfide ○ Total Volatile Organic Compounds (Total VOC's) ○ Ethyl acetate
Fugitive Sources ▪ Screening of red wine ▪ Pressing ▪ Ageing in oak cooperage ▪ Bottling process ▪ Preservation agents	○ Ethanol ○ Sulphur dioxide
Fuel combustion	○ Carbon monoxide (CO) ○ Sulfur dioxide (SO2) ○ Total VOC's ○ Particulate matter (PM10) ○ Oxides of nitrogen (NOx)

3.5.2 Emissions to Water

Emissions of substances to water can be categorised as discharges to:

- surface waters (e.g. lakes, rivers, dams, and estuaries);
- coastal or marine waters; and
- stormwater.

The discharge of listed substances to a sewer or storage dam does not require reporting to the NPI. However, leakage and other emissions (including dust) from liquid storage facilities (e.g. dams and tanks) are reportable.

3.5.3 Emissions to Land

On-site emissions of substances to land include solid wastes; slurries; sediments; spills and leaks; and storage and distribution of liquids that may contain listed substances. These emission sources can be broadly categorised as:

- emissions from surface impoundment of liquids and slurries; and
- unintentional leaks and spills that are not contained and recovered.

Irrigation of wastewater is a common source of emissions of NPI-listed substances to land.

3.5.4 Emission Calculation Techniques

In general, there are four types of emission estimation techniques (EET's) that may be used to estimate emissions from a facility. The four types described in the *NPI Guide* are:

- sampling or direct measurement;
- mass balance;
- fuel analysis or other engineering calculations; and
- emission factors.

When determining pollutant emissions for NPI reporting, other NPI manuals may also need to be used depending upon the facilities that may be on a property. The manuals that may be relevant include:

- combustion in boilers;
- fuel and organic liquid storage (for emissions from fuel storage tanks) and
- combustion engines (e.g. for motor vehicle emissions).

These manuals are on the NPI website (www.npi.gov.au) under 'industry reporting'.

4 POTENTIAL ENVIRONMENTAL IMPACTS OF WINE PRODUCTION

The main potential environmental impacts of wineries are:

- pollution of groundwater and surface water, degradation of soil and damage to vegetation arising from liquid and solid waste reuse and disposal practices;
- odour and air emissions resulting from the management of raw materials, wastewater, solid and semi-solid by-products from the winemaking process; and
- noise from pumps, chillers, crushers and other winery equipment, as well as vehicle noise, particularly during vintage.

Some of the potential environmental impacts of the various constituents of the liquid and solid waste by-products from the winemaking process are summarised in Table 4.

The majority of wineries in Queensland are relatively small family-owned operations and their waste production and hence potential environmental impacts are generally minor and can be managed relatively easily. The level of environmental risk on operation poses will determine the level of management and monitoring that is needed.

TABLE 4 - POTENTIAL ENVIRONMENTAL IMPACTS OF WINERY AND/OR DISTILLERY WASTES

Constituent	Indicators	Effects
Organic matter	BOD[1], TOC[2], COD[3]	▪ Depletes oxygen when discharged into water, leading to the death of fish and other aquatic organisms. ▪ Odours generated by anaerobic decomposition cause nuisance if waste is stored in open lagoons or land applied.
Alkalinity /acidity	pH, Calcium carbonate	▪ Death of aquatic organisms at extreme pH ranges. ▪ Affects microbial activity in biological wastewater treatment processes. ▪ Affects the solubility of heavy metals in the soil and availability and/or toxicity in waters. ▪ Affects crop growth.
Nutrients	Nitrogen, phosphorus, potassium, sulphur	▪ Cause eutrophication or algal bloom when discharged to water or stored in lagoons; algal blooms can cause undesirable odours in lagoons. ▪ N as nitrate and nitrite in drinking water supply can be toxic to infants. ▪ Toxic to crops in large amounts.
Salinity	EC[4], TDS[5], Chloride	▪ Imparts undesirable taste to water. ▪ Toxic to aquatic organisms. ▪ Affects water uptake by crops.
Sodicity	SAR[6], ESP[7]	▪ Affects soil structure, resulting in surface crusting, low infiltration and hydraulic conductivity, hard and dense subsoil.
Metal contamination	Cadmium, chromium, cobalt, copper, nickel, lead, zinc, mercury	▪ Toxic to plants and animal.
Solids	TSS[8]	▪ Reduces soil porosity, leading to reduced oxygen uptake can reduce light transmission in water, thus compromising ecosystem health. ▪ Smothers habitats. ▪ Odour generated from anaerobic decomposition.

Source – EPA, South Australia (2004).

Notes:

1. Biological oxygen demand
2. Total organic carbon
3 Chemical oxygen demand.
4 Electrical conductivity.
5 Total dissolved solids.
6 Sodium adsorption ratio.
7 Exchangeable sodium percentage.
8 Total suspended solids.

5 WINE PRODUCTION PROCESSES AND WASTE PRODUCTION

The quantity and types of wastes produced by a winery vary depending upon the activities undertaken and the waste management practices. The properties of the water used in the winery influences the quality of the effluent stream. For instance, if groundwater with a relatively high salt content is used the effluent would be more saline than if stormwater collected from roofs, paved areas and farm dams were used.

Winery wastewater comes from a number of sources that include:

- cleaning of tanks;
- hosing down of floors and equipment;
- rinsing of transfer lines;
- barrel washing;
- spent wine and product losses;
- bottling facilities;
- filtration units;
- laboratory wastewater; and/or
- stormwater diverted into, or captured in, the wastewater management system.

Wine production is seasonal, and the characteristics of wastewater vary with the production period. Up to six production periods can be defined; these are summarised in Table 5.

TABLE 5 - DESCRIPTION OF WINERY WASTEWATER PRODUCTION PERIODS AT WINERIES[1]

Period[2]	Typical months of the year	Description
Pre-vintage	January - February	Bottling, caustic washing of tanks, non-caustic washing of equipment in readiness for vintage
Early vintage	February - March	Wastewater production is rapidly rising to peak vintage flows and has reached 40% of the maximum weekly flow; vintage operations dominated by white wine production.
Peak vintage	March – May	Wastewater generation is at its peak; vintage-only operations are at a maximum.
Late vintage	April – June	Wastewater production has decreased to 40% of the maximum weekly flow; vintage operations dominated by production of red wines; distillation of ethanol spirit may coincide with this period.
Post-vintage	May - September	Pre-fermentation operations have ceased; effect of caustic cleaning etc. is at its greatest and wastewater quality may be poor.
Non-vintage	June - December	Wastewater generation is at its lowest - generally less than 30% of maximum weekly flows during vintage; wastewater quality is highly dependent on day-by-day activities.

Source – EPA, South Australia(2004).

Notes: 1. Chapman *et. al.*, Winery Wastewater Handbook 2001.

2. The demarcation between one period and another, and the timing or existence of each period, will vary between wineries and regions.

The main issues to be dealt with in relation to winery wastewater and solids are:

1. volume;

2. salinity and sodicity;
3. acidity;
4. variability;
5. stormwater; and
6. solid waste products.

5.1 Volume

Wineries generally produce between 1 ML and 5 ML of wastewater for every 1000 t of grapes crushed. It is not uncommon for small wineries to produce up to 80% of their wastewater during the vintage period.

The total volume of wastewater produced and peak production volume, along with the volume of wastewater that can be irrigated, need to be known to calculate subsequent storage and treatment requirements.

5.2 Salinity and Sodicity

Salinity is the total amount of dissolved salts in the wastewater and is measured as electrical conductivity (EC). The SI Unit of measure for EC is deciSiemens/m (dS/m).

Winery wastewater is generally moderately saline.

Sodicity is when there is an excess of sodium ions relative to calcium and magnesium ions. In wastewater it is measured as the Sodium Adsorption Ratio (SAR).

Cleaning agents, such as chlorine type products and mineral acids can increase the salinity and sodicity of wastewater. Alkali wash-water, cleaning water and product loss can all contribute to salinity in winery wastewater. Alkali wash-water and water used for cleaning can all contribute to the SAR of winery wastewater.

5.3 Acidity

This is a measure of how acidic or alkaline a substance is. The initials pH stand for "Potential of Hydrogen." Acidity is the measure of hydrogen cations (H^+) in a solution on the negative log to base 10 scale. Acids have pH values under 7, and alkalis have pH values over 7. If a substance has a pH value of 7, it is neutral and is neither acidic or alkaline

The extra processing that occurs at the vintage stage generally causes an increase in the pH of the wastewater. When wastewater is stored it generally becomes more acidic (pH reduces) because organic acids are generated during treatment.

5.4 Variability

Wastewater production changes throughout the year (vintage/non-vintage). The waste production also varies between wineries.

During the vintage period the Biological Oxygen Demand (BOD), total nutrients and EC generally increase. The wastewater also generally becomes more acidic.

5.5 Stormwater Runoff

Stormwater runoff from around wineries generally comes from rooved and paved areas. Stormwater should be collected separately from the wastewater to avoid overflows of the wastewater collection and treatment systems (if it has not been factored into the design of the system) and to avoid disruptions to the function of the treatment systems.

The collection of stormwater can be useful in the dilution of winery wastewater (to modify pH and lower salinity).

The first flush stormwater can be directed to the wastewater collection and treatment system to prevent fouling of clean water collected in storage. This is particularly recommended if the first flush water contains substantial amounts of organic matter (leaves) and dust.

5.6 Solid Wastes

Wineries also produce solid wastes. These may include:

- grape marc - the grape material (mainly skin, pulp and seeds) which is left over after grape crushing and pressing;
- lees - the material which accumulates in the bottom of grape juice or wine fermentation tanks;
- filtered solids – generally diatomaceous earth and bentonite clay, filter media;
- stalks – separated from the grapes during the crushing process;
- wastewater sludge - composed mainly of microbial cells and grape residues; and
- general refuse – empty chemical containers, cardboard, plastic containers, wooden pallets, packaging waste etc.

5.7 Best Management Practices

- Measuring volumes of cleaning water used, wastewater produced and wastewater irrigated to improve the overall management of the wastewater storage, treatment and reuse system.
- Avoiding acid and chlorine washing as much as possible as it makes effluent treatment and disposal more difficult. Consider using hot water washing as an alternative.
- Recycling of alkali cleaning solutions (pH 13.5) until the solution becomes frothy (pH ~10.0).
- Storage of wastewater for at least 24 hours before discharge to treatment systems or direct irrigation to avoid variability throughout the day.
- Reducing storage times to help reduce malodour production.
- Using stormwater to operate cooling towers in preference to bore water, as this will substantially reduce the amount of water removal (bleeding) required to stop salts accumulating.

6 WASTE TREATMENT AND STORAGE

The main purpose of a wastewater treatment process is to reduce the organic matter content or Biological Oxygen Demand (BOD). This produces a more stabilised effluent and sludge, reducing associated odour problems during irrigation and solids application.

Wastewater treatment also lowers nitrogen levels through volatilisation of ammonia. The treatment process also usually settles out other nutrients, such as phosphorus.

Treatment processes include solids separation or settling, anaerobic treatment, aerobic treatment and composting of solid by-products.

Problems with wastewater treatment generally result from poor maintenance, system overloading, irregular flow rates, excessive holding times before treatment and inappropriate design.

If a relatively stable wastewater is produced and if there is adequate suitable land available for disposal and there is a low risk of surface water contamination, groundwater contamination and odour impacts, wastewater treatment before irrigation may be unnecessary.

Wineries also produce a range of solid by-products including grape marc, lees, filtered solids, stalks and wastewater sludge. These materials can be directly applied to land or composted to improve their suitability for land spreading, provided potential impacts to natural resources and amenity are managed.

6.1 Anaerobic Treatment

Anaerobic treatment systems rely upon bacteria that do not survive in the presence of oxygen. Enzymes produced by these bacteria initially breakdown complex organic compounds into soluble acids (e.g. acetic acid). In a second stage, hydrogen combines with the acetic acid to form methane. Carbon dioxide is also produced and is emitted or converted to bicarbonate. For optimal bacterial growth the pH needs to remain between 6.6 and 7.3 (neutral). Some less digestible materials are not broken down and deposit in the base of the treatment system as sludge that needs to be periodically removed.

If the anaerobic decomposition process is incomplete the second digestion stage does not proceed. This results in the production of offensive odour by-products such as intermediate organic acids, hydrogen sulphide and ammonia.

6.2 Aerobic Treatment

Aerobic treatment requires a plentiful supply of oxygen to support the aerobic bacteria. With aerobic pond treatment this oxygen is supplied by diffusion from the air and oxygen-producing algae in the pond. The concentration of organic matter in winery wastewater means that a true aerobic pond will not always be possible without mechanical aeration. This aeration can be expensive. Aerobic ponds also tend to produce more sludge than anaerobic treatment ponds.

The main advantage of aerobic treatment is that the bacterial digestion tends to be more complete and odour free than anaerobic digestion. Sequencing Batch Reactors (SBRs) are an example of an aerated treatment system that is in use at wineries.

6.3 Composting

Composting is a natural aerobic process involving the breakdown of organic matter by micro-organisms. The resultant product is a humus-like material that is a valuable organic fertiliser and soil conditioner. The composting process is optimised through the provision and control of water, oxygen, nitrogen (manure) and carbon (litter) levels in the substrate. Because composting is an aerobic process, odour generation is very low compared to anaerobic treatment or storage.

Solid wastes are generally composted in windrows about 1.5 m high and about 2-3 m wide at the base. To maintain enough oxygen, the windrows generally require weekly turning. If windrows are not turned weekly, the process may still proceed, just more slowly. The process should be complete in about 6-8 weeks, with an additional 4 weeks of curing time. By maintaining the correct moisture content (around 50-55% wet basis) and oxygen concentration (through turning), the compost should reach and maintain temperatures of 60-65°C. This temperature should be sufficient to destroy most weed seeds and pathogens. However, it is important that the windrow is completely turned to ensure all of the material is exposed to these temperatures.

6.4 Best Management Practices

- Designing treatment systems to handle both the organic and volume loading expected, particularly during peak periods (i.e. vintage period).
- Measuring organic loads and caustic soda use to assist in planning treatment systems, utilisation practices and any associated monitoring.
- Developing cleaning procedures to reduce the amount of wastewater and the components of wastewater.
- Keeping winery effluent separate from wastewater generated from cellar door and food preparation activities, due to health concerns.
- Maintaining optimum pH of treatment systems by:
  - adding lime;
  - separating out caustic soda wastewater (alkaline) and adding this to the effluent at a later stage to increase pH;
  - separating out highly acidic wastes and stabilising these separately with pH modifiers; and
  - premixing wastewater with larger volumes of neutral pH wastewater or clean water before irrigating.
- Sealing the base of wastewater storage and treatment ponds to avoid leaching of nutrients and organic matter to groundwater.
- Sealing the base of solid waste storage or composting areas to avoid leaching of nutrients and organic matter to groundwater <u>or</u> undertaking composting under a rooved structure.
- Ensuring solid waste storage and composting areas are bunded to avoid runoff of nutrients and organic matter to surface waters.
- Maintaining any composting operation within optimum parameters to avoid excessive odour production.

7 WASTE UTILISATION OR DISPOSAL INCLUDING IRRIGATION PRACTICES

The general characteristics of winery wastewater that are likely to most limit safe reuse through land irrigation are:

- volume – total annual amount and peak discharges (vintage);
- salinity (salts);
- sodicity;
- nutrient loading – nitrogen (N), phosphorus (P), potassium (K) etc;
- acidity; and
- variability.

Winery wastewater is usually used to irrigate vines, crops, pastures and lawns. Irrigations need to be effectively managed to avoid the leaching of salts, nutrients and organic matter. This is achieved by using the most limiting factor (i.e. volume, organic load, nutrients (N and P), salinity, sodicity and pH) to control irrigation rates.

7.1 Volume

Irrigations need to be carefully managed to prevent nutrient leaching through excessive drainage, waterlogging (the displacement of air in soil pores with water) and unnecessary runoff.

The amount of water that can be applied during irrigation depends upon the crop demand and the soils water holding capacity. Only a portion of the soil-stored water, the Readily Available Water (RAW), can be utilised by plants before water stress occurs. The RAW holding capacity of the soil is the amount of water required to take the soil from the refill point (stage where soil moisture slows growth) to field capacity (point where the soil can not hold more water). The amount of RAW depends upon factors like soil texture, root depth and distribution.

Different soil types absorb water at different rates dependent on infiltration rates. For example, coarse sandy soils will infiltrate water much faster than heavy clay soils. If the irrigation system is not designed to match the volume applied to the infiltration rate through the soil, losses can occur through evaporation and runoff.

7.2 Salinity

Salts added to the soil accumulate when the amount of salt added is not balanced by losses through drainage. Soil salinity occurs when there are sufficient soluble salts within the profile to reduce the potential for water to pass into plant roots, causing dehydration. Plant yields may drop by 20-30% before the signs of salinity are noticeable, although the effect is more obvious in dry years or if plants appear to be water stressed when water should not be a limitation. However, crops vary in their salinity threshold, with some affected at a lower soil salinity than others. This limits the type of crops and pastures that can be grown, as different plants have differing abilities to take up saline water. Shaw *et al.* (1987) developed a salinity tolerance classification scheme that sorts plant species by the salinity at which a 10% yield reduction occurs. It includes five soil salinity ratings. Average root zone salinity coupled with four soil texture classes, or water uptake weighted salinity, can be used with this scheme. This is shown below.

Soil Salinity Criteria as EC_{SE} Corresponding to a 10% Yield Reduction for the Plant Salt Tolerance Groupings of Maas & Hoffman (1977) and the Equivalent $EC_{1:5}$ for Four Ranges of Soil Clay Content

Plant Salt Tolerance Grouping	EC_{se} Range (dS/m)	Corresponding $EC_{1:5}$ Based on Soil Clay Content (dS/m)				Soil Salinity Rating
		10-20% clay	20-40% clay	40-60% clay	60-80% clay	
Sensitive crops	<0.95	<0.07	<0.09	<0.12	<0.15	Very low
Moderately sensitive crops	0.95-1.9	0.07-0.15	0.09-0.19	0.12-0.24	0.15-0.3	Low
Moderately tolerant crops	1.9-4.5	0.15-0.34	0.19-0.45	0.24-0.56	0.3-0.7	Medium
Tolerant crops	4.5-7.7	0.34-0.63	0.45-0.76	0.56-0.96	0.7-1.18	High
Very tolerant crops	7.7-12.2	0.63-0.93	0.76-1.21	0.96-1.53	1.18-1.87	Very high
Generally too saline for crops	>12.2	>0.93	>1.2	>1.53	>1.87	Extreme

(Shaw *et al.* 1987).

Some individual salts (e.g. chloride, sodium and boron) may cause leaf burn or defoliation when they accumulate in the leaves. They may also reduce the availability of calcium and magnesium, producing deficiency symptoms. Salinity also degrades soil structure, encouraging scalding and promoting erosion. If crop yields are reduced significantly bare soil patches may form which further increases the erosion hazard.

Use of saline irrigation water poses a risk to the quality of underlying groundwater through the leaching of salts through the soil profile and to surface waters receiving saline runoff or salt-rich eroded soil.

7.3 Sodicity

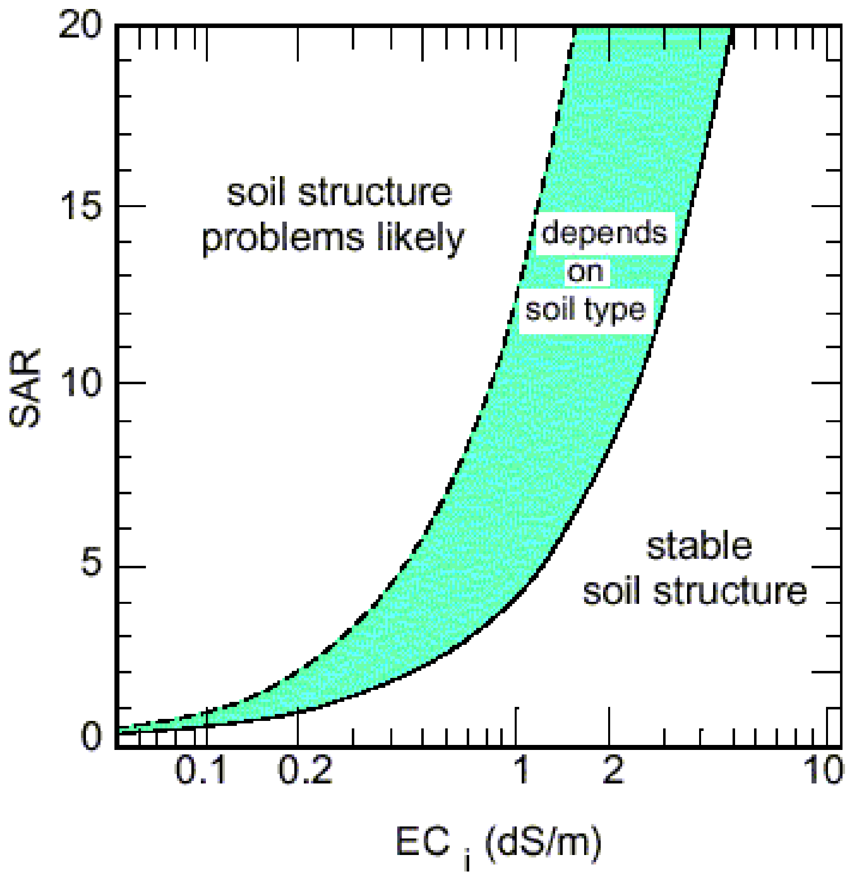
Soil sodicity occurs when the ratio of exchangeable sodium ions to other exchangeable cations in the soil, or Exchangeable Sodium Percentage (ESP), is sufficient to influence the swelling and dispersion behaviour of the soil. Displacement of the clay particles in the soil reduces soil macroporosity which prevents soil aeration, reduces the amount of water that is readily available for uptake by plants, reduces soil permeability and may lead to waterlogging. The soil is also less stable and more erodable.

Australian soils are generally classed as non-sodic if the ESP is less than 6, sodic if it is between 6 and 15 and strongly sodic if the ESP exceeds 15. However, the actual ESP at which soil dispersion increases depends upon the soil properties. For instance, an ESP of 3 may trigger sodicity in unprotected surface soils that are subject to water erosion while a subsoil ESP of 15 may be acceptable for a heavy clay soil. Sandy soils tend to have higher ESP thresholds for sodicity than clay soils. Saline soils also tend to have higher ESP thresholds for sodicity since the electrolyte levels in the soil solution inhibits clay swelling and dispersion. Nevertheless, any soil ESP determination of 6 should trigger investigation.

Irrigating with effluent that has a high SAR may induce sodicity. The first step in preventing the onset of sodicity through effluent irrigation is to identify whether the effluent SAR-EC combination is likely to trigger soil swelling and dispersion. Figure 1 shows the effect of a range of SAR-EC combinations on soil structure and clearly identifies the combinations that are most likely to induce soil structural instability and least likely to induce soil structural problems. Irrigation with effluent with an SAR-EC range fitting between the two curves on

Figure 1 may induce soil structural problems, depending on the soil type. The risk is greater in heavier soils that drain less readily.

FIGURE 1 - PREDICTION OF SOIL STRUCTURAL STABILITY USING SODIUM ABSORPTION RATIO (SAR) AND EC FOR IRRIGATION WATER (SHAW, 1994)



Gypsum is commonly used to amend sodicity in non-saline soils. It adds calcium which displaces sodium ions from clay particles. For alkaline soils, growing acidifying legumes may be a cost effective way to enhance gypsum effectiveness. Sulfur additions are an alternative if there is sufficient calcium carbonate at the sodic depth. For acidic, sodic soils, lime can improve soil structure and raise the pH. Increasing and maintaining soil organic matter levels also improves structure and helps to reduce erosion rates.

Since sodic soils have lower infiltration rates, it helps to apply irrigations at slower rates. The aims of wastewater dilution prior to irrigation should be to produce an EC that does not depress plant yields and an EC-SAR combination that is unlikely to trigger soil sodicity. However, while irrigating saline sodic wastewater may prevent sodicity in the short term, amelioration will probably be needed when effluent irrigations cease. This is because water leaching through the soil will reduce the total salt content of the soil solution more rapidly than it will reduce the ESP, leading to clay swelling and dispersion.

7.4 Nutrients

The important macronutrients to consider when irrigating wastewater are nitrogen, phosphorus and potassium. These elements are essential for plant growth. Micro-organisms will absorb nitrogen and phosphorus in the preferred forms of nitrate and phosphate. However, most nitrogen and phosphorus in winery wastewater is in the organic form and not immediately available to the plant after irrigation.

When nitrate levels exceed the immediate needs of the soil organisms, soil microbes and plant roots it has the potential to leach into groundwater. Thus the application of nitrogen (wastewater and inorganic additions) needs to be carefully balanced to avoid excessive leaching.

Phosphate is different to nitrogen as it tends to bind to the surface of clay particles and organic matter. Phosphate that is unavailable to the plants can build up in the surface soil. When the surface soil becomes saturated with phosphate it can leach through the soil profile, particularly in sandy soils.

7.5 Acidity

Acidification is most likely to occur within the zone wetted during irrigation, and directly affect plant vigour and yield by:

- reducing the availability of plant nutrients (particularly phosphorus and calcium); and
- decreasing populations of useful microbial populations.

A minimal benchmark for irrigation water is a pH of 5.5. This is the lower limit tolerated by most plants and beneficial microbial populations.

7.6 Variability

As winery wastewater is often a composite of many waste streams the concentrations of some elements and components may vary widely. There may be excessive levels of BOD, salinity, sodicity, acidity and alkalinity. Hence, it is often beneficial to blend waste streams or to dilute the waste streams before irrigation to offset these effects.

When irrigating vines, loss of vigour and quality is likely to occur if any of the following benchmarks are exceeded:

- volumes greater than the needs of the vine;
- frequent application where BOD exceeds 2000 – 3000 mg/L;
- carbon to nitrogen ratios of less than 15:1;
- carbon to phosphorus ratios of less than 30:1 or phosphorus applications exceeding 100 kg/ha;
- salinity levels exceeding 1.5 dS/m for own-rooted vines (these can be higher for salt excluding rootstocks); and
- pH outside the range of 5.5-8.5.

7.7 Best Management Practices

- Measuring wastewater irrigation rates.
- Minimising water losses in the irrigation system by applying water precisely and efficiently (particularly for vineyards).
- Maximising water use efficiency by matching water requirements to crop water requirements, the water holding capacity in the rootzone and the amount required for the leaching of salts.
- Developing and implementing an Irrigation Management Plan (IMP) particularly for facilities that undertake intensive wastewater irrigation, or are located in sensitive areas. This IMP can form part of the Environmental Management System for the enterprise.
- Applying wastewater at a rate similar to the plant removal rate. Daily water requirements can be estimated from a water balance (otherwise referred to as water budget) that considers the irrigation and rainfall contributions; canopy interception of rainfall; depth of active root zone; crop water requirements (crop factor x evaporation and as-measured with calibrated soil water monitoring devices); salt leaching requirements to ensure that soil salinity levels do not exceed crop tolerance; and efficiency of irrigation systems.
- Managing irrigation lines to avoid the build-up of salts and bacteria.
- Pre-treating or diluting wastewater for irrigation if the BOD level exceeds 7000 mg/L so as not to deplete oxygen levels in the soil and enable the oxygen level to recover post-irrigation.
- Diluting wastewater for irrigation if salinity levels are excessive.
- Providing amelioration to soil affected by sodicity through applying:
  - gypsum at 2-6 t/ha every year or two (higher rates if soils are alkaline soils, strongly sodic or have high water inputs);
  - sulfur if there is sufficient calcium carbonate at the sodic depth. Adding sulfuric acid to the effluent for irrigation will address sodicity in soils with reasonable calcium and magnesium levels. (Sulfuric acid is dangerous); or
  - lime at 1-4 t/ha (lower rates for lighter soils) to acidic, sodic soils.
- Matching nutrient application rates to plant requirements and avoiding a build-up of nitrate and phosphate in the soil.
- Avoiding the irrigation of wastewater with a pH of less than 5.5.

8 ECO-EFFICIENCY MEASURES IN WINE PRODUCTION

Eco-efficiency is a business oriented approach to environmental management. It focuses on reducing resource inputs and avoiding the generation of wastes and pollutants. Eco-efficiency not only provides improved environmental performance but also financial savings and increased competitiveness in a market where consumers are more environmentally aware.

Following are some measures that can improve the efficiency of an operation, whilst minimising potential downstream environmental impacts.

8.1 Water Use

- Use high pressure, low volume with high temperatures during washing, rather than low pressure, high volume cold water that will use substantially more water.
- Use of On/Off nozzles on hoses can substantially reduce water use by avoiding the delay in switching hoses on and off.
- Using stormwater rather than borewater in cooling towers can substantially reduce bleed rates if the water has a significantly lower initial salinity.
- Using collected stormwater for cleaning purposes where there is no potential contact with wine products.
- Using collected stormwater runoff (particularly paved and roofed areas) for use in gardens etc, rather than relying on groundwater resources.
- Using mulches to lower soil evaporation rates around trees and vines to lower evaporative losses and hence water requirements.
- Using drip or underground irrigation to reduce evaporation losses.
- Using soil probes or similar devices to determine appropriate timing and rate of irrigation.

8.2 Energy Consumption

- Using energy efficient lighting wherever possible.
- Using solar water heating.
- Insulating all heating elements and exchangers and hot water pipes to reduce heat loss and energy consumption.
- Insulating fermentation tanks to improve refrigeration efficiency.

8.3 Material Use

- Recycling used materials (e.g. cardboard) wherever possible.
- Recirculating cleaning materials wherever possible.
- Reducing chemical use within the winery.
- Minimising the use of inorganic fertilisers.
- Minimising the use of herbicides and insecticides.

8.4 Emission of Pollutants

- Irrigating wastewater rather than using evaporation for wastewater disposal as the latter will produce greater gaseous losses (e.g. ammonia volatilisation).

8.5 Quantity of Materials/Waste

- Reducing the quantity of materials to landfill. Participating in the Australian DrumMuster Program ensures safe disposal of all chemical containers
- Composting solid organic by-products wherever possible.

The Case Studies (Appendix A) detail practical examples of eco-efficiency measures that have been implemented at wineries in Queensland. This appendix also details other environmental management initiatives that have been implemented at both a winery and industry scale in Australia and overseas.

9 ENVIRONMENTAL MONITORING

Environmental monitoring, including results interpretation against sustainability indicators, is critical to the overall environmental management of a winery. It provides a mechanism to assess the effectiveness of the strategies chosen to minimise potential environmental harm.

It is important to recognise that it is extremely difficult to develop tools for determining and demonstrating sustainability and indicators of sustainability that cover all situations. The tools for determining sustainability will probably overstate the likely environmental risk in some cases. Consequently, where a significant level of environmental risk or impact is identified, it is critical to confirm that this result is accurate through further investigation or action.

9.1 Wastewater

To accurately determine the characteristics and quantity of various elements applied during the irrigation of wastewater, the monitoring schedule needs to reflect changes during the production period. It needs to be performed at a suitable location before irrigation, preferably at the pump after any mixing with dilution water, has occurred. Typical parameters for analysis are detailed in Table 6.

TABLE 6 - PARAMETERS TO BE ANALYSED IN WASTEWATER

Parameters	Standard units
BOD	mg/L
Total N	mg/L
Total P	mg/L
Total K	mg/L
EC	dS/m
pH	pH units
Sodium[1]	mg/L
Magnesium[1]	mg/L
Calcium[1]	mg/L
Sodicity	SAR
Chloride	mg/L
Total suspended solids[2]	mg/L
TOC[3]	mg/L
COD[3]	mg/L
Sulphate[4]	mg/L
Carbonate[5]	mg/L
Bicarbonate[5]	mg/L

Notes:

1. To be used in determining SAR.
2. Solids may generate odours upon anaerobic decomposition and may result in the clogging of drippers.
3. Although BOD is the accepted environmental pollution indicator, TOC or COD can provide a quicker indication of irregularities in the wastewater system.
4. Sulphate reduction under anaerobic conditions may generate odours; measurement may only be necessary where wastewater is stored in open tanks and lagoons.
5. Precipitation with calcium can lead to white scale formation and clogging of drippers; measurements of these parameters will also allow for determination of alkalinity and Adjusted SAR.

9.2 Soil chemistry

The accuracy of soil monitoring data relies highly on the sampling methods and techniques employed and hence should be undertaken only by qualified professionals or suitably trained and/or experienced persons.

Any monitoring locations should be properly marked to enable samples to be collected at locations adjacent to previous sampling points for valid comparison of results.

Two samples for each dominant soil type should be collected once a year (preferably in September or October) from different depths, which take into account the soil profile physical variation. For each sample, collect composite portions taken from at least two sampling points to obtain a more representative result.

The following depths can be taken as a guide for sampling:

- Topsoil - separate samples from the following soil layers:
  a. 0 to 20 cm; and
  b. 20 to 60 cm
- Subsoil - typically from 60 cm to bottom of the rootzone or depth of first impeding layer.

Typical parameters for analysis are detailed in Table 6.

TABLE 7 – RECOMMENDED SOIL ANALYSIS PARAMETERS

Soil test parameter	Depth (Down profile)	Justification
pH		Influences nutrient availability
EC_{se} (Can measure $EC_{1:5}$ and convert to EC_{se})$^{+}$	0.0 – 0.2 m 0.2 – 0.6 m 0.6 - base of root zone	Measure of soil salinity
Nitrate-N	0.0 – 0.2 m 0.2 – 0.6 m 0.6 - base of root zone	Measure of nitrogen available for plant uptake
Available phosphorus (Colwell or Olsen or Bray or BSES or Lactate or Calcium Chloride or Other)	0-0.2 m	Measure of phosphorus available for plant uptake
Organic Carbon	0-0.2 m	Influences soil stability and consequently soil erosion
Exchangeable cations and CEC (Calcium, sodium, potassium, magnesium).	0-0.2 m 0.6 m - base of root zone	Needed to calculate ESP, EKP and Ca: Mg which have important implications for soil structure

$^{+}$ EC_{se} levels in the top soil layers are not intended to be a direct sustainability indicator, but will provide useful agronomic information and provide a guide to soil salt movements.

Measuring chloride at 0.6 m - base of root zone may also be warranted if further investigations or actions for salinity are required.

9.3 Groundwater

The irrigation of wastewater should not produce detrimental impacts to groundwater quality. If groundwater contamination is suspected or the wastewater irrigation site is located near shallow or sensitive groundwater, a monitoring program should be undertaken to measure any potential impacts.

Table 8 provides a list of the Australian drinking water quality guidelines for constituents commonly found in winery wastewater. If groundwater sampling identifies levels outside these limits, further investigation should be undertaken. The figures in Table 8 provide guidelines for measuring water quality in recreational and drinking water.

TABLE 8 - GUIDELINES FOR MEASURING RISK IN RECREATIONAL AND DRINKING WATER (NHMRC, 2004 AND ANZECC AND ARMCANZ, 2000)

Parameters	Guideline Value	Basis
pH	6.5 – 8.5 [b]	Optimal for most organisms
Total Dissolved Solids (mg/L)	1000[a]	Taste problem
Sodium – Na (mg/L)	300[a], 180 [b]	Taste problem
Chloride – Cl (mg/L)	400[a], 250[b]	Taste problem
Sulphate (mg/L)	500[a], 250[b]	Taste problem
Oxygen (mg/L)	>80% saturation	Prevents foul odour and taste
Nitrate (as NO_3)	50[a]	Toxicity – particularly infants

[a] – Human health
[b] – Aesthetic

When measuring the sustainability indicators for groundwater the following should be used:

1. not cause a 50% increase from upgradient levels OR
2. exceed values in Table 8.

9.4 Solid By-products and Compost

Winery operators have a duty of care to ensure that any solid by-products from the operation are used sustainably. Sampling and analysis of these products will assist in determining appropriate application rates. Analysis results can also be provided to end-users of products if these go off-site. Information supplied to end-users and records of sales should include fact sheets that provide typical or actual composition. The quantities and destination of any off-site sales should also be recorded.

Suggested analysis parameters for solid by-products and compost include:

- total nitrogen (TN) or total Kjeldahl nitrogen (TKN);
- ammonium nitrogen (NH_4N);
- nitrate-nitrogen (NO_3N);
- total phosphorus (TP);
- potassium (K);
- carbon (C);
- pH; and
- electrical conductivity (EC).

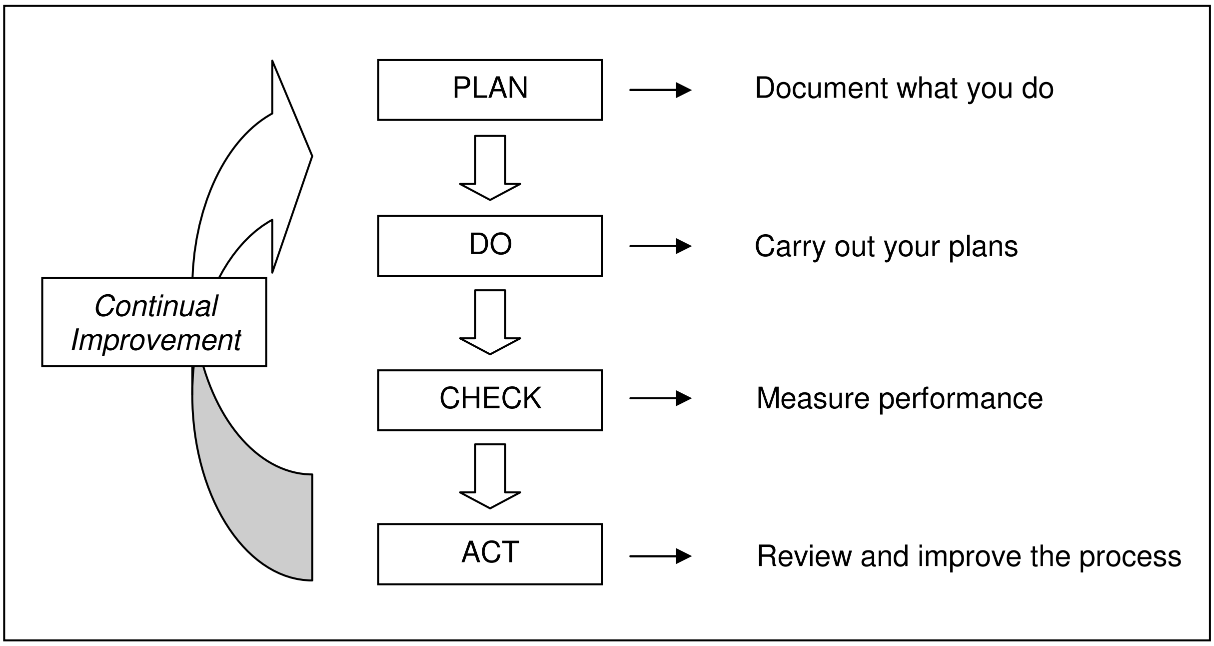
9.5 Best Management Practices

- Developing a wastewater IMP that includes monitoring and recording the dates, paddocks, quality and quantity of wastewater irrigated and that reflects the changes in wastewater produced during the production cycle.
- Monitoring volumes and chemical analysis of any uncontrolled releases of wastewater.
- Regularly monitoring (at least annually) areas that have received wastewater and comparing the results against background monitoring sites (areas that have not received wastewater and where other fertilisers have not been applied) to identify any issues with nutrient levels, sodicity and salinity.
- Monitoring (annually) long-term trends in soil pH. A neutral (7) to slightly acidic (6) pH soil is optimal for plant growth. Irrigation of winery wastewater may alter soil pH. Monitoring should initially occur annually however, the frequency can be reduced if levels remain within the optimum range and stable.
- Obtaining advice on sustainable application rates of wastewater from a qualified agronomist or soil scientist.
- Measuring potential groundwater impacts if the wastewater irrigation area is located on a site with shallow groundwater, or light soils or the site is sensitive.
- Recording details of all off-site transfers of solid by-products and compost, including the destination, quality and quantity.

10 ENVIRONMENTAL MANAGEMENT SYSTEMS

An Environmental Management System (EMS) is voluntary and is that part of an organisations management system used to develop and implement its Environmental Policy and manage its potential environmental impacts.

EMS provides a management framework based on a simple plan, do, check, act cycle that achieves continual improvement.



An EMS includes organisational structure, planning activities, responsibilities, practices, procedures, processes and resources, for developing, implementing, achieving, reviewing and maintaining the environmental policy, objectives and targets of the organisation.

As part of the organisation EMS the waste hierarchy should be adopted, with wastes managed in the following priority order:

1. avoid;
2. reduce;
3. reuse;
4. recycle or reclaim;
5. treat; and
6. dispose.

10.1 Environmental Policy

The Environmental Policy is a declaration of the organisation's commitment to sound environmental management, good environmental performance and continuous improvement. It should include a commitment to:

i. Pollution prevention.

ii. Continual improvement.

iii. Compliance with relevant environmental legislation, regulations and voluntary commitments.

10.2 Legal Requirements

This component should identify and list the legal and other requirements, including licences and applicable legislation (e.g. *Environmental Protection Act 1994, Water Act 2000, Vegetation Management Act* 1999).

10.3 Potential Environmental impacts

Potential environmental impacts in the following areas should be considered (list is not exhaustive):

1. soils of utilisation areas;
2. groundwater quality and availability;
3. surface water quality and availability;
4. community amenity (odour, dust, noise);
5. flora & fauna; and
6. items, sites and places of cultural heritage significance.

10.4 Environmental Objectives

Environmental Objectives, along with Environmental Targets and Environmental Action Plans, provide the means to facilitate continual improvement. Setting Environmental Objectives involves both an understanding of the environmental risks associated with the operation and the degree of environmental performance desired.

10.5 Environmental Targets

Environmental Targets should relate specifically to a particular Environmental Objective and should be time bound. Each Environmental Target should provide detailed performance requirements that are quantifiable.

10.6 Environmental Action Plans

Environmental Action Plans (EAPs) are established to assist in achieving documented Environmental Objectives and Environmental Targets. EAPs allow an organisation to measure environmental performance against the Environmental Objectives and Environmental Targets. They also provide specific plans (steps) needed to achieve the targets, the name of the person who is responsible for implementing each plan and when each plan or step will be implemented.

10.7 Organisational Structure

The organisational structure includes the roles and responsibilities for all employees required to implement an EMS. An organisation should appoint a specific representative to:

1. Ensure the EMS is established, implemented and maintained; and
2. Report to management on the performance of the EMS to enable review including recommendations for continual improvement.

10.8 Competency and Training

An organisation should undertake a training needs analysis which:

1. Ensures all personnel receive training appropriate to their role and responsibilities;
2. Identifies the specific environmental and other competencies required to properly and efficiently undertake all tasks or activities;
3. Lists all positions or personnel who will be responsible for those tasks or activities;
4. Identifies the existing competencies of all personnel. This might include completed formal education, training and work experience; and
5. Is used to create a training plan for the organisation.

All training undertaken should be documented.

10.9 Monitoring and Measuring Performance

An organisation should establish and maintain a procedure for monitoring and measuring environmental performance and ensuring compliance with legal requirements. This will involve monitoring those activities with the potential for causing significant adverse environmental impacts.

Any monitoring equipment must be calibrated (or verified as being accurate against a calibrated piece of equipment) and maintained with records of these activities being retained.

10.10 Corrective and Preventative Action

Plans for Corrective and Preventive Actions should be developed to address actual and potential areas of environmental impact.

An organisation should establish and maintain procedures for:

1. Defining responsibility and authority for handling and investigating issues;
2. Taking action to mitigate any adverse environmental impacts caused;
3. Initiating and completing corrective and preventive action, and recording results of actions taken;
4. Documenting any corrective or preventive actions taken and reviewing their effectiveness; and
5. Modifying and recording any changes in the documented procedures resulting from corrective or preventive actions.

10.11 Internal Auditing

An organisation should regularly review the performance of the EMS to determine whether it has been properly implemented and maintained. The results of the audit must be documented and provided to management. The audit program, including any schedule must consider the environmental performance or significance of environmental impacts as well as the results of previous audits.

10.12 Management Review

An organisation should review the performance of the EMS annually to ensure that it continues to be suitable, effective and adequate. The Management Review process should be documented and consider possible changes to all elements of the EMS.

11 References and Bibliography

Australian and New Zealand Environment Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC and ARMCANZ). 2000. National Water Quality Management Strategy 4a – Australia and New Zealand Guidelines for Fresh and Marine Water Quality. New Zealand Environment and Conservation Council and the Agriculture and Resource Management Council of Australia and New Zealand. ISBN 0 9578245 2 1. ISSN 1038 7072. October 2000.

Bond, W.J. 1998. "Effluent Irrigation – An Environmental Challenge for Soil Science", Australian Journal of Soil Research, 7 January 1998, accessed from Northern Light Web Browser, Special Collection, Document ID UU20020107100046705.

Chapman, J, Baker, P and Will, S. 2001. *Winery Wastewater Handbook: Production, Impacts and Management*, Winetitles Publishers, Adelaide, South Australia.

Charman, P. E. V. and Wooldridge, A.C. 2000. "Soil Salinisation", Chapter 13.3 in Charman, P. E. V. and B. W. Murphy "Soils: Their Properties and Management", Second Edition, Oxford University Press, South Melbourne, pp. 237-245.

Department of Environment and Heritage. 2005. The Emission Estimation Technique Manual for Wine and Spirit Manufacturing. 18 May 2005. www.npi.gov.au.

Department of Tourism, Fair Trading and Wine Industry Development. 2004. Queensland Wine Industry Development Strategy. December 2004. http://www.dtftwid.qld.gov.au/Wine/Wine+Strategy/Wine+Strategy.

Environmental Protection Agency. 2004. Operational Policy – Environmental Operations. Material change in intensity or scale for an environmentally relevant activity (ERA).

Environment Protection Authority – South Australia. 2004. EPA Guidelines for Wineries and Distilleries.

Environmental Protection Act 2004. Queensland Parliamentary Counsel. http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProtA94.pdf.

Environmental Protection (Air) Policy 1997 (EPP Air). Queensland Parliamentary Counsel. http://www.epa.qld.gov.au/environmental_management/planning_and_guidelines/policies_and_strategies/protection_policies/#Environmental%20Protection%20(Air)%20Policy%201997.

Environmental Protection (Noise) Policy 1997 (EPP Noise). Queensland Parliamentary Counsel. http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProtNoPo97_02A_030424.pdf.

Environmental Protection (Water) Policy 1997 (EPP Water). Queensland Parliamentary Counsel. http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProWatePo97_02A_030424.pdf.

Environmental Protection (Waste Management) Policy 2000 (EPP Waste). Queensland Parliamentary Counsel. http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProtWaMP00_02A_030424.pdf.

Environmental Protection (Waste Management) Regulation 2000. Queensland Parliamentary Counsel. http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProtWaMR00_002_021108.pdf.

Environmental Protection Regulation 1998. Queensland Parliamentary Counsel. http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/E/EnvProtR98.pdf.

Integrated Planning Act 1997. Queensland Parliamentary Counsel. http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/I/IntegPlanA97.pdf.

Lines-Kelly, R. 2000. "Soil Sense: Soil Management for NSW North Coast Farmers", North Coast Soil Management Working Group, 2nd edition.

National Health and Medical Research Council and Agriculture and Resource Management Council of Australia (NHMRC). 2004. National Water Quality Management Strategy - The Australian Drinking Water Guidelines. ISBN Print: 186496118X. ISBN Online: 1864961244. http://www.nhmrc.gov.au/publications/_files/awgfull.pdf.

SalCon. 1997. "Salinity Management Handbook", Department of Natural Resources Queensland, Brisbane.

Rengasamy, P. and Churchman, G.J. 1999. "Cation Exchange Capacity, Exchangeable Cations and Sodicity", Chapter 9 in Peverill, K.I., L.A. Sparrow and D.J. Reuter (eds) "Soil Analysis: an Interpretation Manual", CSIRO Publishing, Collingwood.

Rengasamy, P and Bourne, J. 1997. "Managing Sodic, Acidic and Saline Soils", Cooperative Research Centre for Soil and Land Management, Glen Osmond.

Shaw, R.J., Brebber, L. Ahern, C. and Weinand, M. 1994. "A Review of Sodicity and Sodic Soil Behaviour in Queensland", Australian Journal of Soil Research, **32**: 143-172.

Shaw, R.J., Hughes, K.K., Thorburn, P.J. and Dowling, A.J. 1987. "Principles of Landscape, Soil and Water Salinity – Processes and Management Options. Part A." In "Landscape, Soil and Water Salinity". Proceedings of the Brisbane Regional Salinity Workshop, Brisbane, May 1987. Queensland Department of Primary Industries Conference and Workshop Series QC87003. Brisbane.

Vegetation Management Act 1999. Queensland Parliamentary Counsel. http://www.legislation.qld.gov.au/LEGISLTN/ACTS/1999/99AC090.pdf.

Water Act 2000. Queensland Parliamentary Counsel. http://www.legislation.qld.gov.au/LEGISLTN/ACTS/2000/00AC034.pdf.

Appendix A. CASE STUDY EXAMPLES

Sirromet Wines

Sirromet is Queensland's largest winery and the headquarters are located at Mount Cotton, halfway between Brisbane and the Gold Coast. The operation combines a fully operating vineyard, winery, cellar door and restaurant. Sirromet Wines first opened to the public in July 2000.

As well as treating waste generated from the winery, the facility has a large restaurant that generates wastes that need to handled and treated. At Sirromet Wines there are two liquid wastestreams. One is an anaerobic sewage plant, which includes a storage and treatment area, sand filtration and an ultraviolet lamp.

The other wastestream is from the winery. It is treated through a plant that utilises solids removal, pH correction, sedimentation, mixing and aeration.

After each wastestream is treated separately, the two streams are blended. The aim of treating the wastestreams separate before combining them is to lower BOD, COD and *E. coli* levels before irrigation.

The winery has a number of concrete tanks each with a storage capacity of 100 kL. Each of these contains a mixer and aerators to enable dissolved oxygen to be injected. These tanks have a hydraulic retention time of 5 days to enable the degradation of bugs, and to lower the BOD and nutrient levels. During the vintage five of these tanks are used and outside the vintage this reduces to three tanks. Running the wastewater treatment system in this manner enables the microbes used in the treatment process to remain populated and active.

The winery also operates a worm farm for managing all solid waste from skins, stems and paper, grasses and other fruits. It also takes all non-meat scraps from the restaurant.

The wastewater is blended with stormwater runoff from a dam at a rate of 75% dam water with 25% wastewater. This irrigation volume matches the irrigation demand of the vines on the property. Every three months, influent and effluent from the waste treatment plant is tested and every two years the soil is tested as per the EPA licence.

Eco-efficiency Measures at Sirromet

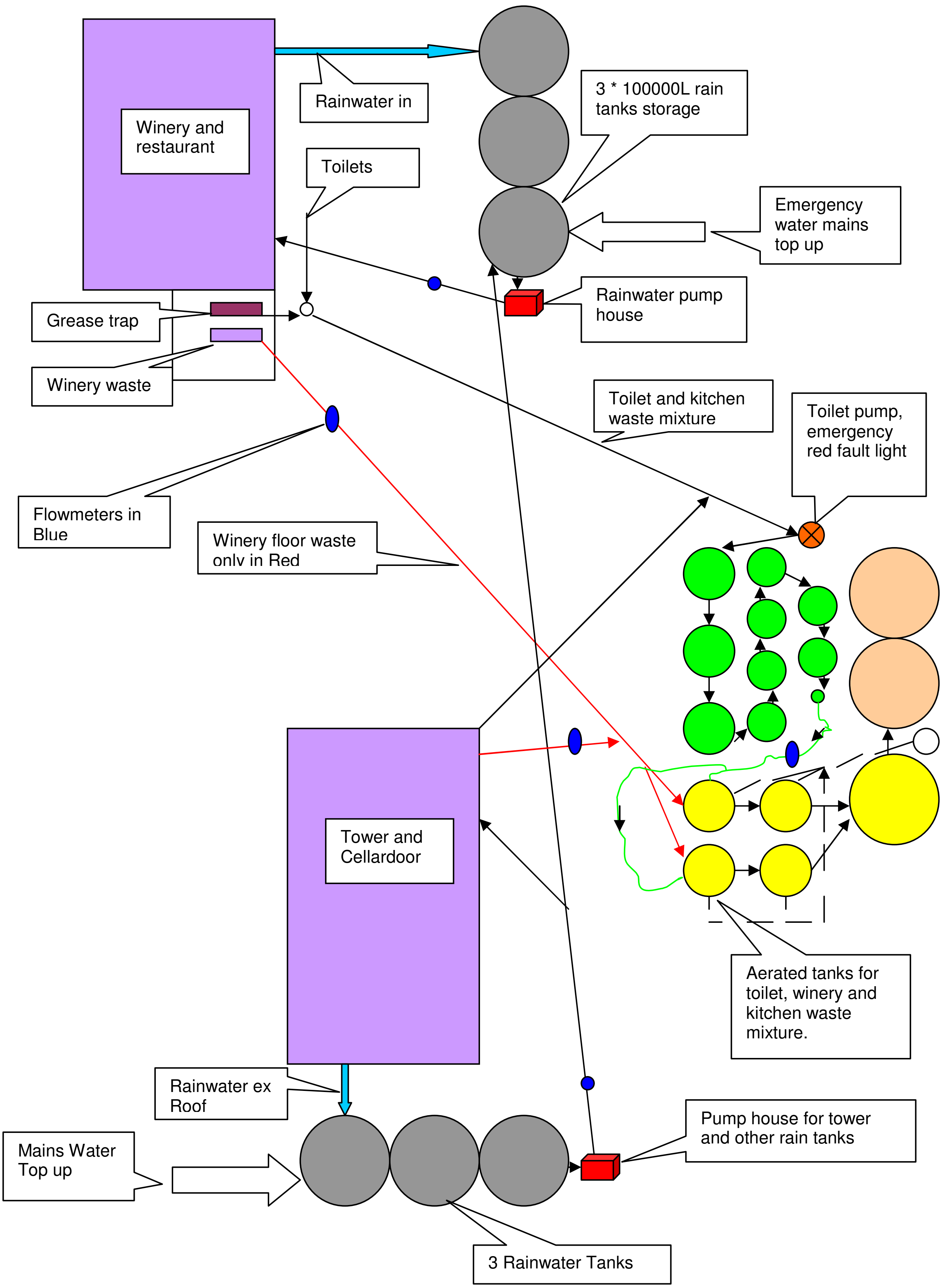
To reduce the use of reticulated water at the site all floors are washed with treated dam water. All other surfaces are cleaned with treated rain water.

Excess water from the treatment plant is applied to the worm beds to maintain the optimal moisture content. A roof with sufficient overhang is used to prevent direct sunshine onto the beds and hence evaporation losses.

No paper and cardboard is dumped in landfill, but is instead recycled in the worm farm.

Water flow meters are used throughout the operation to optimise water use in each section of the facility.

The following diagram shows the wastestream and treatment system used at Sirromet.


Rainwater in
Winery and restaurant
Toilets
3 * 100000L rain tanks storage
Emergency water mains top up
Rainwater pump house
Grease trap
Winery waste
Toilet and kitchen waste mixture
Toilet pump, emergency red fault light
Flowmeters in Blue
Winery floor waste only in Red
Tower and Cellardoor
Aerated tanks for toilet, winery and kitchen waste mixture.
Rainwater ex Roof
Mains Water Top up
Pump house for tower and other rain tanks
3 Rainwater Tanks

Rimfire Winery

The Rimfire winery and vineyard is located at Maclagan, approximately one hour north-west of Toowoomba on the way to the Bunya Mountains. The winery and vineyard is a family operation run by the Connellan family. Rimfire is part of a large grazing and cropping farm (approximately 1550 ha).

Rimfire owns its own picker that it exclusively uses at its facilities. It is estimated that the mechanical picking reduces crushing waste by approximately 80%.

The fermented and unfermented by-products are generally mulched with the grape seed. This mulch is used mainly on the extensive garden beds. Waste sludge is collected from the bottom of tanks into a tanker and is spread on the extensive areas of grassland on the property. All effluent is collected in a drain and is flood spread on a vegetative filter area below the winery. Solid waste from the crushing is collected in bins and hand applied to the farming land.

Eco-efficiency Measures at Rimfire

The biggest energy consumption at Rimfire winery is electricity for refrigeration and the pumping of water. The winery uses a combination of rainwater, bore water and a 200 ML stormwater collection dam. This dam is located 3.5 km from the winery and hence pumping costs can be very significant. The 330 m deep bore supplements the surface water supply.

The three water sources are used for various purposes, so the winery is set-up with three separate water pipelines. All rinsing uses rainwater, while the floors are generally cleaned with borewater.

Cleaning is preferentially performed with chemicals that don't require additional rinsing, hence saving on water use. The use of high pressure and low volume cleaning reduces overall water use.

The vineyard is entirely under drip irrigation, with soil probes extensively used to monitor soil-water and determine irrigation scheduling. These strategies assist in minimising water usage.

The storeroom is built into the side of a hill to take advantage of the natural insulation properties of the earth and reduce on heating and cooling costs. It is also fitted with a 150 mm polystyrene insulated door.

The winery is constructed of insulted wall panelling for ease of cleaning and to reduce heating and cooling costs.

The newer fermentation tanks located outside of winery are covered over the top and insulated with 75 mm of polyurethane to reduce energy (refrigeration) costs.

Yalumba

As a wine business operating in the rural environment for 150 years, the Yalumba Wine Company recognises the impact of its activities on the environment and the long-term effects of these impacts on the sustainability of its business.

Yalumba uses the ISO14001 standard as a model for developing an environmental management system. This means that the company not only meet its legal obligations but also integrates environmental objectives into relevant business decisions in a cost-efficient manner and address environmental responsibilities as part of normal operating procedures. A practical environmental improvement program is developed and implemented to identify, quantify and minimise significant impacts through a program of continuous improvement and environmental monitoring.

As part of the environmental program, suppliers are also encouraged to reduce their environmental impacts by adopting clean technology and best practice procedures. Furthermore, Yalumba also seeks to encourage its customers to dispose of product packaging in an environmentally responsible manner.

Yalumba's EMS is a systematic approach to managing actual or potential impacts on the environment. It provides Yalumba with a management framework to achieve continuous improvement through a 'plan, do, check, act' cycle within which best business practices can be integrated. An EMS is essentially about corporate governance - the way in which a business is organised and held responsible. Yalumba's EMS is managed by a certified environmental practitioner, demonstrating the organisation's commitment to a high standard in ethical and environmental practice.

Yalumba recognises waste minimisation and pollution prevention as a core requirement of responsible entrepreneurship. Yalumba has a solid waste reduction and recycling programme and continues to explore best available technology economically achievable to reduce, recycle and reuse wastewater produced from its operations. Under South Australia's Environment Protection Act winemaking operations are subject to agreed licence conditions aimed at minimising significant environmental impacts from the management of winery by-products.

Sustainable Winegrowing New Zealand (SWNZ) Initiative

New Zealand's small population, isolated location and agricultural economy have earned the country a "clean green" image. New Zealand grape growers and winemakers aim to maintain this image by protecting the environmental integrity of their wine production. To achieve this a set of industry standards have been developed. These are known as Sustainable Winegrowing New Zealand (SWNZ).

SWNZ was developed to provide a "best practice" model of environmental practices in the vineyard and winery to guarantee better quality assurance from the vineyard through to the bottle and to address consumer concerns in matters pertaining to the environment.

The introduction of a winery audit has enabled SWNZ to broaden the scope of the program to provide a framework for companies to continually work towards improving all aspects of their performance in terms of environmental, social and economic sustainability in both the vineyard and the winery.

The environmental issues that arise in wineries and are covered in the audit include resource management, waste management and process management. The program uses a combination of monitoring, measuring, and recording, incorporated with staff training. There are other environmental issues to be included in the future, all part of the continuous improvement process. For example, it is anticipated that waste management will be extended to include packaging, its disposal and recycling.

A similar approach to that taken in the vineyard has been adopted for wineries. A technical manual comprised of fact sheets for each management area and best practice recommendations has been developed. Wineries are able to rate their performance and ultimately benchmark themselves against like-minded companies. External auditing of the winery will verify that sustainable practices are carried out in the winery.

Wineries passing an external audit and meeting all of the wine accreditation requirements will be able to use SWNZ endorsements on wine bottles to verify their commitment to environmentally responsible production.

California Code of Sustainable Winegrowing Practices (SWP)

In 2003, the wineries and wine growers in California developed a Code of Sustainable Winegrowing Practices (SWP). This code aims to promote grape growing and winemaking practices that are sensitive to the environment and responsive to the needs and interest of society in general. The SWP Joint Committee decided to use a generalised framework that allows the code to be adapted and aligned to specific frameworks (i.e. ISO 14001) in the future.

This voluntary code addresses issues such as reduced pesticide use, water and energy conservation, waste reduction and recycling, control of erosion, creating and maintaining a habitat for wildlife around the vineyards, planting cover crops to replenish the soil with nutrients and other measures for making high quality wines in a responsible manner.

A 490-page workbook has been created to help wineries implement the practices and the Wine Institute and the California Association of Winegrape Growers (CAWG) have conducted workshops throughout the state.

More than 120 workshops have been held throughout California to support the industry's implementation and expansion of sustainable practices. Vintners and growers meet together to review the workbook and use the self-assessment criteria to evaluate their vineyard and winery operations. Vintners and Growers also attend follow-up action plan workshops to address specific topics such as integrated pest management and ecosystem management. More than 900 growers and 160 winery operations have participated in the workshops and more than half have submitted their evaluation forms to the project.