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Treated Wastewater Reuse – an opportunity for the meat industry

1. Introduction

Environmental management is one of the key issues facing the meat industry in the late 1990s.

An increasing community awareness and concern with environmental issues and the occurrence of large-scale environmental problems in Australia, such as the Murray-Darling toxic blue-green algal bloom, has led to a greater focus on environmental management (Johns & Greenfield, 1993). This focus has resulted in the appearance of more stringent environmental legislation throughout Australia (Pitt & Skerman, 1993).

One of the major outcomes of the environmental legislation is the requirement for industry to operate in an ecologically sustainable manner.

The new Queensland Environmental Protection Act (EPA 1994) places greater accountability on licence holders for environmental performance. For example, the Act provides for stiff penalties for those who fail to comply with environmental licence standards. The penalties include:

- Up to $500,000 fine for organisations;
- Individuals can be jailed for up to two years; and
- Chief Executive Officer liability.

The new legislation is also forcing the meat industry to reassess the way it treats and disposes of wastewater. The great majority of traditional lagoon treatment and irrigation systems currently used at meat processing facilities are unlikely to comply with the requirements of the Act.

Most lagoon treatment processes have been designed for removal of organic material (BOD_5) but do not achieve significant nutrient (i.e. nitrogen and phosphorus) reduction. Irrigation systems have usually been designed on an hydraulic loading basis although many do not have enough area to be environmentally sustainable. Overloaded irrigation systems can result in runoff of contaminated water to waterways or drainage to groundwater. Both these impacts can produce unacceptable environmental degradation.

Sustainable wastewater irrigation must take into consideration both hydraulic and nutrient loadings. Because of the high nutrient levels in effluents from traditional lagoon treatment systems, nutrients have the potential to govern the size of an irrigation area. Either a much larger irrigation area will be required or nitrogen and phosphorus reduction needs to be incorporated into wastewater treatment. In either event, the cost of treatment and disposal of wastewater will increase significantly.

To meet the challenge of good environmental management, the meat industry will need to employ a holistic approach to the task at hand. An environmental management system for wastewater incorporating the following principles (in descending order of importance) is required:

- Minimisation;
- Reuse;
- Treatment; and
- Disposal.

This paper focuses on the opportunities that the reuse of treated wastewater can provide the meat industry while, at the same time, achieving cost effective compliance with new legislation.

2. Definitions

High grade Non-Potable Water: Reclaimed wastewater which is of a microbiological potable water standard.

Non-Potable Water: Water that is not fit for human consumption as defined by Regulation 95.1 of the Export Meat Orders.

Potable Water: Water that is fit for human consumption as defined by Regulation 95.1 of the Export Meat Orders.

Raw water: River or ground water which is the source of water supply.

Reclaimed water: Treated wastewater which has undergone additional treatment to bring it to a standard suitable for high grade reuse within the meatworks (e.g. potable water).

Secondary treatment: Wastewater treatment processes including but not limited to conventional lagoon and activated sludge systems.

Treated wastewater: Effluent from conventional lagoon or activated sludge wastewater treatment systems. Treated wastewater is then usually disposed by irrigation or discharged to a receiving water.

Wastewater: Liquid effluent from areas within the meatworks containing contaminants such as solids, organic matter, nutrients and micro-organisms.

3. Wastewater Reuse opportunities

3.1 General

In identifying treated wastewater reuse opportunities it is important to identify water uses within a meatworks and the water quality required for these uses. According to Australian Quarantine and Inspection Service's (AQIS')' Export Meat Orders (the Orders) water use in a meatworks can be divided into both non-potable and potable.

3.2 Non-Potable Water

Order 94.1 stipulates that non-potable water is restricted in meatworks to the following uses:

- ammonia condensers;
- vapour lines serving coolers used for rendering material not fit for human consumption;
- cleaning of condemned material or material not fit for human consumption;
- stockyard washing;
- moving of solid materials in sewer lines;
- initial washing of live animals provided that potable water is used for the final wash.

Non-potable water use represents only 10 to 20 per cent of total water use within a meatworks. As such, recycling of non-potable water, by itself, represents only a relatively minor percentage of the total water use in a plant.

3.3 Potable Water

Water used within a meatworks for purposes other than those presented in Section 3.1 is required to be of potable water quality.

The following are examples of where potable water is required:

(i) Human consumption and food preparation;
(ii) Hand washing, showering and laundering;
(iii) Carcass, viscera, casings processing and other edible product washing;
(iv) Edible rendering;
(v) Knife and equipment sterilisation;
(vi) Washdown in the edible meat processing areas (e.g. slaughter floor, chillers and boning rooms);
(vii) Toilet flushing;
(viii) Boiler and cooling tower make-up water; and
(ix) Stock watering.

In contrast to non-potable use (as defined by Order 94), up to 80 to 90 percent of water utilised within a meatworks must be of potable water quality.

Therefore, for treated wastewater recycling to be maximised, the treated wastewater needs to be able to be used for some of the uses which require a potable water quality.

4. Water Quality Standards

4.1 General

Prior to assessing what additional treatment is necessary to produce potable and non-potable water from treated wastewater, it is important to study water quality standards.

4.2 Non-Potable Water Quality

There is no specified minimum water quality standard for non-potable water. Order 94 identifies where non-potable water can be used, but does not specify a quality.

Order 94 would seem to imply that any wastewater quality is suitable as non-potable water. However, it is suggested that a minimum water quality standard should also be set for non-potable reuse within a meatworks. Where there is a risk of the non-potable water splashing upon workers, the NHMRC/AWRC 'Guidelines for Use of Reclaimed Water in Australia (1987)' should be adopted. This guideline suggests that wastewater needs to be treated by some form of secondary treatment and disinfected to achieve a microbiological quality of 1000 faecal coliforms/100 mL. Treated wastewater from any meatworks treatment lagoon or activated sludge process with subsequent disinfection should comply with this guideline.

4.3 Potable Water Quality

Potable water quality is defined in Order 95.1 which states that it shall:

(a) Not contain any substances or micro-organisms in amounts that are hazardous to human health;
(b) Comply with Schedules 2, 3, 4 and 5 of Guidelines for Drinking Water Quality in Australia (NHMRC/AWRC 1987); and
(c) Have the following microbiological quality:
Total coliforms < 10/100 mL
E.Coli < 1/100 mL

A summary of Schedules 2, 3, 4 and 5 of NHMRC/AWRC 1987 Drinking Water Guidelines is presented in Table 1.

Table 1 Summary of Schedules 2,3,4 and 5 of drinking water guidelines (NHMRC/AWRC, 1987)

Schedule	General Description	Health Status	Members of Schedule
2	Physical quality	NOT DIRECTLY HEALTH RELATED	e.g. colour, turbidity, taste and odour, pH
3	Organic chemical quality	HEALTH RELATED	e.g. pesticides, chlorophenols, aromatic hydrocarbons, chlorinated alkanes and alkenes
4	Inorganic chemical quality	HEALTH RELATED	e.g. nitrate, arsenic, cyanide and heavy metals including cadmium, chromium, lead and mercury
5	Inorganic chemical quality	NOT DIRECTLY HEALTH RELATED	e.g. aluminium, chloride, copper, hardness, iron manganese, sodium and sulphate, total dissolved salts, zinc

It is worth noting that Schedule 2 - Physical (aesthetic) quality and Schedule 5 - Inorganic chemical quality are NOT directly health related compared to Schedule 3 - Organic chemical quality and Schedule 4 which are health related.

It is also worthy of note that the Guideline values on the health related Schedules 3 and 4 have been derived on the basis of chronic toxicity. That is, the guideline value has set a value which will pose no significant risk to the health of a consumer over a lifetime (70 years) of consumption (NHMRC/ARMCANZ, 1994). The guidelines values are very conservative, and are calculated using a range of safety factors (NHMRC/ARMCANZ, 1994).

In summary, Order 95.1 requires potable water in a meatworks to comply with microbiological, inorganic and organic chemical health-related criteria as well as aesthetic and other inorganic non-health related criteria.

There appears to be some conflict between Order 95.1, the regulation which defines potable water, and Order 98 which is concerned with non-compliance of a potable water supply. Under Order 98, a potable water is in non-compliance if it does not meet the microbiological criteria (i.e. E Coli and total coliforms) set out in Order 95.1(c). However, there are no non-compliance provisions for potable water which does not meet the physical, organic or inorganic chemical quality as set out in Order 95.1(b) and NNMRC/AWRC Drinking Water Quality Guidelines (1987). Herein lies the problem with the regulations. A potable water

quality as per Order 95.1 must have acceptable physical, inorganic and organic chemical, and microbiological water quality but non-compliance is based on only one aspect of that water quality, namely microbiological quality. To be consistent, either the non-compliance regulation (Order 98) should be upgraded to contain additional non-compliance provisions for physical, inorganic and organic chemical aspects of water quality, or if microbiological water quality is considered to be the key criteria for an acceptable water quality, physical organic and organic chemical quality schedules should be removed from Order 95.1(b).

It is contended that both of the above options apply a blanket water quality criteria to all water reuse as defined as 'potable' water by Orders 94 and 95.1 and therefore, are inappropriate.

4.4 Risk Management Approach to Water Use

A risk management approach and not a blanket water quality standard approach should be applied to individual water uses within a meatworks. It is likely that a risk assessment will show that, although many uses within a meatworks do require a potable water standard as defined by Order 95.1, there are other uses that require a standard which is of a microbiological potable water quality standard but do not need to comply with physical, inorganic and organic chemical water quality, as defined by Order 95.1.

To illustrate this point, consider the water uses of human consumption and washdown water. Clearly, water which is to be consumed by workers must be aesthetically pleasing, microbiologically safe, and ensure reduced risk for long-term consumption (chronic toxicity). A water quality as defined by Order 95.1 is thus considered appropriate.

Washdown water, however, must be of a quality which will not contaminate the product as the result of splashing. The greatest potential risk of contamination of edible meat from splashed washdown water is microbiological infection. The washdown water would need to be of a microbiological standard equivalent to drinking water (as per Order 95.1(c)). Washdown water would also need to be sufficiently low in organic and inorganic chemical constituents that it would not cause surface contamination of meat. However, because it is not concerned with chronic toxicity, it would not need to comply with Order 95.1(b). It is likely secondary treated wastewater with some additional treatment (refer Section 5) will have low inorganics and organics and therefore would be a negligible risk to product. Although not directly health related, the washdown water should have low colour and good clarity (low turbidy). The washdown water, however, would not need to comply with the other physical (aesthetic) criteria in Order 95.1(b). Thus while this water quality is of a very high standard, it would not currently comply with all of the requirements of potable water as defined by Order 95.1.

As will be discussed in Section 5 and 6, a high grade non-potable water, which is suitable for applications such as washdown, can be produced from wastewater by a simpler and cheaper method than 'potable' water as defined by Order 95.1.

It is subsequently agreed that there be three grades of water permitted in a meatworks:

- Low grade non-potable (as per Order 94.1);
- Highgrade non-potable (as proposed); and
- Potable water (as per Order 95.1).

5. Potable Water Reclamation Plant

5.1 Background

To produce 'potable' water, additional treatment of the wastewater would be required. This additional treatment is often called 'water reclamation'.

While there are no reported technology developments or trials for the reclamation of treated wastewater from meatworks for potable water reuse (Johns, 1993), there have been several potable water reclamation plants established overseas. Most have treated domestic treated wastewater to a potable water standard. Most notable of these are Windhoek

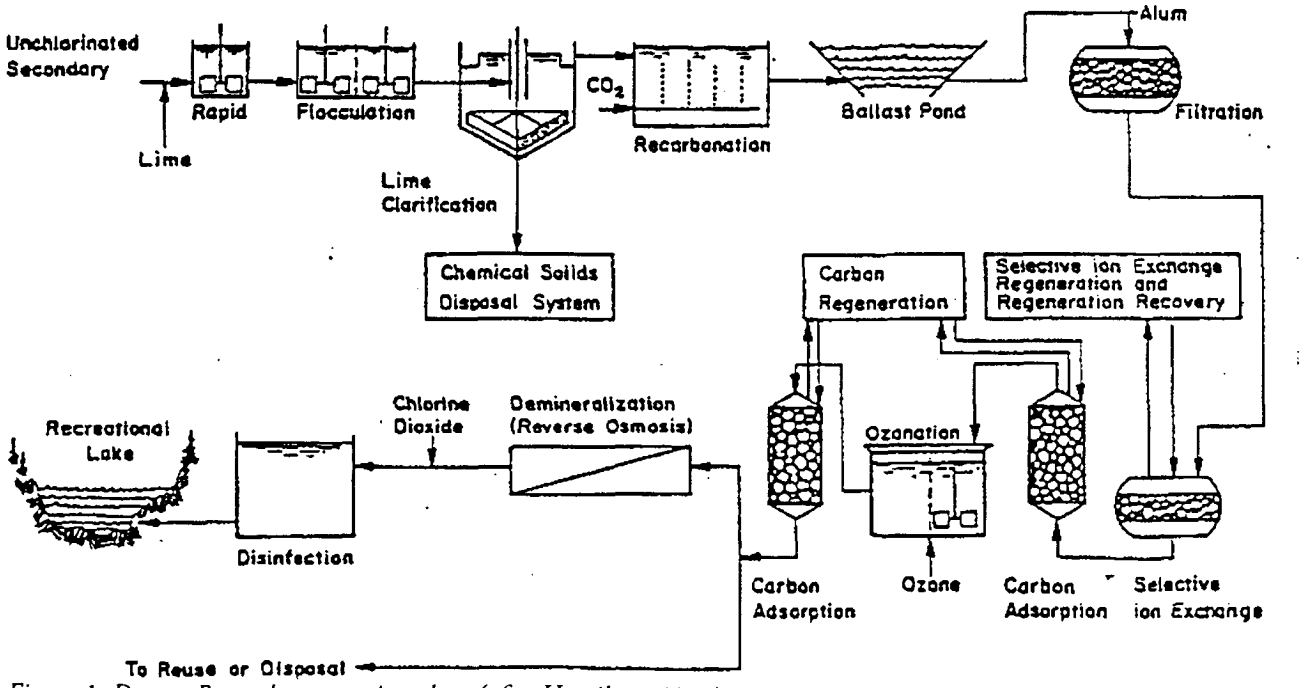

Figure 1 Denver Reuse demonstration plant (after Hamilton, 1993)

(Namibia) and Denver (USA). The Windhoek Potable Water Reclamation Plant which has been operating successfully for over 10 years, supplies 4.5 ML/d of potable grade reclaimed water directly into the city's water supply network (Hamilton, 1991).

The Denver demonstration project has operated for approximately 10 years, producing 1 ML/d of potable grade reclaimed water.

Both plants produced potable water of a grade equal and often better than the normal water supply.

However, these first generation potable water reclamation plants were very conservative in design. For example, the Denver demonstration plant (Figure 1) was designed with a multiple barrier design philosophy to ensure that the removal of any contaminant is guaranteed by more than one unit operation (Lauer *et al*, 1991).

Potable water reclamation processes are being simplified as experience is gained and improved wastewater treatment systems such as biological nutrient removal are being used (Johns, 1993).

5.2 Community Acceptance

Although the technology has been available to produce potable reclaimed water from wastewater, lack of community acceptance has been the major factor in the failure of many proposed large scale potable water reuse projects throughout the world.

At present, in South East Queensland, there is an increasing awareness of potable water reuse as a viable means of supplementing water supplies and reducing wastewater discharges. Gold Coast, Toowoomba, Caboolture, Redland and Noosa Councils have investigated potable water reuse as part of domestic water supply infrastructural planning. The Australian Water and Wastewater Association (AWWA), Queensland Branch, have applied to the Queensland Departments of Primary Industries (QDPI - Water Resources) and Environment and Heritage (QDEH) for funding to construct and operate a potable water reuse demonstration plant as a public education tool. This activity would indicate there is a greater acceptance of potable water reuse.

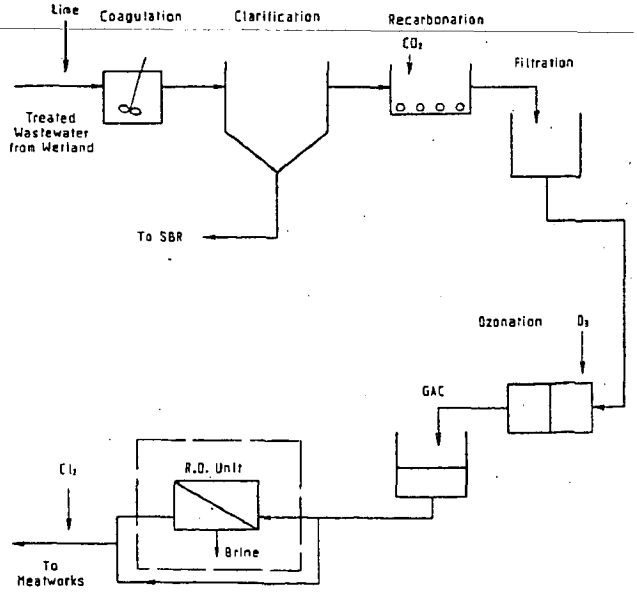

Figure 2 Proposed meatworks potable water reclamation plant
NB R.O. unit may be omitted if salinity reduction is not required

5.3 Proposed Potable Water Reclamation Process

The following potable water reclamation process (Figure 2) is proposed as being suitable for meatworks applications:

- High lime coagulation/flocculation;
- Sedimentation;
- Recarbonation;
- Dual media filtration or micro filtration;
- Ozonation;
- Granular Activated Carbon Adsorption;
- Reverse Osmosis (for high recycle 50 - 85% only); and
- Chlorination.

The water produced from this process would comply with the potable water standard, as defined by Order 95.1, in all aspects and could supply up to 85 percent of water needs within a meatworks.

This process has less unit operations than first generation potable water reclamation processes. The proposed process would be less costly than earlier plants, but would be more costly compared to traditional treatment and disposal method such as irrigation or river disposal. (Indicative costs are discussed in Section 7).

6. Highgrade Non-potable water reclamation plant

A high grade non-potable water reclamation plant which meets potable grade microbiological water quality standards as well as turbidity and colour standards would contain the following unit processes:

- Alum coagulation/flocculation;
- Sedimentation
- Dual media filtration or micro filtration;
- Ozone or U.V. primary disinfection; and
- Chlorine secondary disinfection.

Figure 3 shows a process flowsheet of the proposed process.

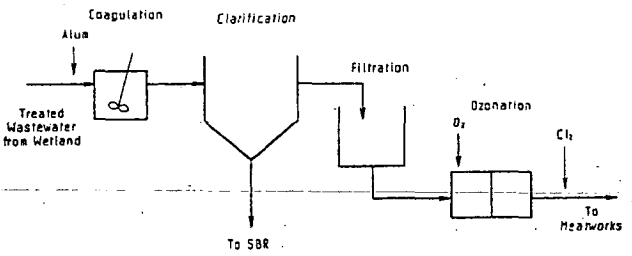

Figure 3 Proposed high grade non-potable water reclamation plant

This proposed process is similar to a conventional potable water treatment works but with the addition of a double disinfection system. Double disinfection will ensure the water is, microbiologically, of a potable water grade. It should be noted that the main difference between this process and the potable water reclamation process (Section 5) is that it has less contaminant safety barriers.

This high grade non-potable water would be better than the potable water currently being used in many meatworks, especially those which use unprotected source water.

High grade non-potable would be suitable for washdown, toilet flushing and lower grade non-potable uses (as per Section 3.2) and could conservatively provide between 40 - 70 percent of the meatwork's water requirements. If the use of cleaning and other chemical

products containing potentially toxic inorganic and organic chemicals could be controlled within the meatworks, this high grade non-potable water could also be used for carcass, viscera and other edible meat washing, thereby increasing reuse potential above 80 percent. Treated wastewater reuse of this magnitude will greatly reduce raw water requirements and the quantity of wastewater to be disposed. Because reuse tends to build up total dissolved salts (TDS) in the water, the TDS level may dictate the upper limit of reuse. With the addition of reverse osmosis or other demineralisation processes, this highgrade non-potable water would also be suitable for boiler and cooling water.

7. Indicative costs of treated wastewater reuse options

Wastewater treatment, disposal and reuse investigations need to be applied on a case by case basis because of the different costs of raw water, irrigation land etc.

An indicative relative capital cost comparison for meatworks wastewater treatment and disposal methods is presented in Figure 4. The costs are based on meatworks which produces 3500 kL/d of wastewater.

From Figure 4, Option B, it can be seen that a 50% non-potable water reclamation and reuse scheme has similar capital costs to an environmentally sustainable irrigation disposal system (Option A). Potable water reclamation and reuse Options C and D have higher capital costs compared to the irrigation and high grade non-potable water reclamation options. As discussed in Section 5, capital costs for potable water reclamation plants will reduce as experience is gained and technology improves.

An indicative total cost (capital and operating costs) comparison for the hypothetical meatworks is presented in Figure 5. The analysis is based on a 10 year period and an 8% discount rate. The graph shows non-potable high-grade recycling is marginally cheaper than a sustainable irrigation system and both options are cheaper than the potable water reclamation processes.

8. Local industry, market and regulatory implications

To obtain local industry acceptance, potable and high-grade non-potable water reclamation and reuse must be proven to be: cost effective; not pose an unacceptable risk of contamination to meat product; and be acceptable to markets.

Market acceptance, especially from the European Union, would be the greatest obstacle for potable and non-potable water reclamation and reuse. There is less likely to be market resistance to the production of a potable reclaimed water which complies with the existing standards as stipulated in Order 95.1. However, the use of a high grade non-potable water which is of a microbiological potable water standard, may not be as easily accepted by the markets. The industry would need to show that this quality water would not result in the contamination of meat products.

For potable and high grade non-potable water reclamation and reuse to be accepted, approval from AQIS would be required. The Export Meat Orders would have to be amended to cater for the proposed three grades of water: low grade non-potable, high grade non-potable and potable (as outlined in Section 4). AQIS approval is likely to be predicated on market acceptance.

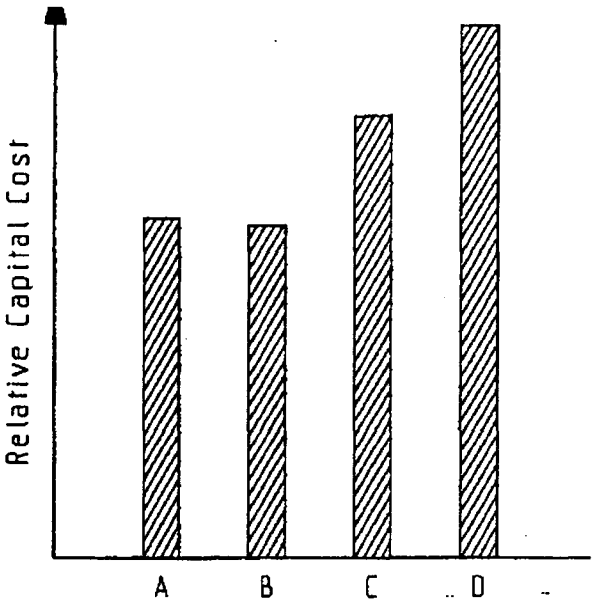

Figure 4 Relative capital costs of treated wastewater reuse and disposal options

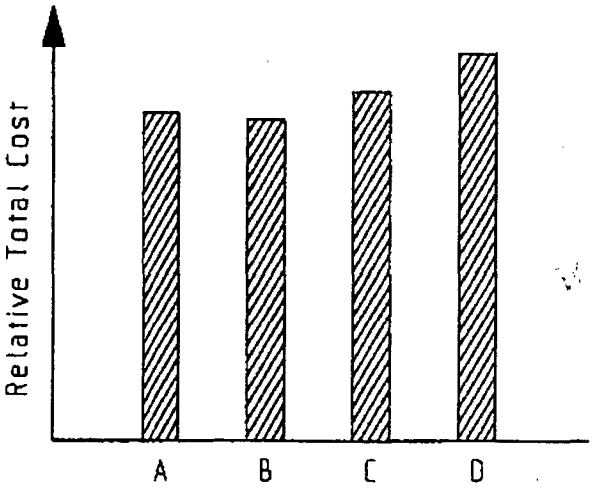

Figure 5 Relative total costs of treated wastewater reuse and disposal options

Legend:

A 0% reused/ – 100% irrigation
B 50% reused – high grade non-potable / 50% irrigation
C 50% reused – potable without demineralisation / 50% irrigation
D 80% reused – potable with demineralisation / 20% irrigation

9. Conclusions

1. Treated wastewater reuse provides the meat industry with an opportunity to achieve cost effective compliance with environmental obligations.
2. The existing regulations in the Export Meat Orders relative to water quality need to be reviewed because:

- There seems to be a discrepancy between Orders 95.1 and 98;
- There does not seem to be a minimum water quality defined for non-potable water (Order 94); and
- The present water quality standard for potable water, which is based on a blanket potable water quality, is too stringent for some water uses within a meatworks.

3. The water quality requirements for water uses within a meatworks should be assessed using a risk management approach.
4. Water quality grades are suggested within a meatworks:
   - Low grade non-potable;
   - High grade non-potable; and
   - Potable.
5. A potable water reclamation process can produce an acceptable 'potable' water from treated wastewater, although it is expensive at this time. Costs of such processes will reduce as experience is gained in their operation and technology improves.
6. An economical, high grade non-potable water reclamation process will produce a microbiological quality equal to drinking water and is likely to be able to supply up to 40 to 70 percent of water demand within a meatworks.
7. Local industry, regulatory and market acceptance would be required before treated wastewater reuse could be permitted.
8. Funding should be made available to further investigate potable and high-grade non-potable water reclamation and reuse.

10. Acknowledgements

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