Townsville City Council

Environmental Assessment

Alternative Waste Treatment Technologies

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Document History and Status

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1 INTRODUCTION

Identifying the most cost-effective way to achieve environmental benefits is a challenge faced by all levels of government. For Townsville City Council, a better understanding of the environmental and economic performance of waste management services was sought in order to better improve the decision making process. In particular, the Council sought information on the costs and benefits of recycling service options compared with the adoption of an alternative waste treatment technology.

The environmental assessment compares the performance of recycling system options in Townsville with the environmental performance of options for alternative treatment of waste. The benefits of the various systems are measured against a landfill-only scenario.

In order to understand the environmental performance of the various waste management options, the method of life cycle assessment has been used.

This assessment has involved:

1. Characterisation of the technology system, as well as the kerbside and product systems associated with recycling;
2. Application of existing LCA data for waste treatment processes[1] and recycling[2];
3. Life cycle impact assessment;
4. Development of a common economic indicator; and
5. Data interpretation and reporting.

The environmental life cycle data for waste technologies records the pollutant loads per tonne of waste for each treatment technology. These have been applied to the Townsville region on a per household basis. This data has then been aggregated into environmental impact categories for meaningful comparison.

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[1] Nolan-ITU (1999) Residual Waste Stabilisation and Pretreatment Study – technical, environmental and economic assessment; Nolan-ITU (2002) Decision Support System for Integrated Resource Recovery

[2] Nolan-ITU (2001) Independent Assessment of Kerbside Recycling in Australia, National Packaging Covenant Council

2 METHODOLOGY

2.1 System characterisation

2.1.1 Systems Boundary

When comparing alternatives using life cycle assessment, the same system boundary is applied to all alternatives. For the environmental assessment of waste treatment technologies, the boundary is from the point of waste receipt, through mechanical processing units and all subsequent unit processes including gas and effluent treatment, through to end-product recovery. The analysis is based on the short surveyable time for landfill of 100 years[3]. By-product recovery is included within the systems boundary and, as such, the extraction, transport and refining of by product substitutes such as coal fired electricity are included in the emission credits. Also included are emissions from landfilling of residuals from the process. A generic site location is assumed and therefore transport of residual waste to the processing technology is not included in the study.

It is important to note that the boundary of the study is restricted to the core technology and may exclude important costs which arise outside this system such as less waste avoidance (which may arise if the adoption of one technology discourages waste avoidance at source) or less transport use.

2.1.2 The Functional Unit

The "functional unit" is the function that the systems must fulfil in order to be comparable. For the purpose of this study, the functional unit is the management of waste per household in the Townsville region.

The different treatment technologies reviewed are considered to be of a similar level of "best practice" with process waste treatment equipment configured to comply with stringent environmental regulations.

[3] Finnveden, G,. Treatment of Solid Waste in Life Cycle Assessment – Some Methodological Aspects, Workshop on LCA and Treatment of Solid Waste September 1995. Swedish Environmental Research Institute, Stockholm, Sweden.

2.1.3 Data Quality

There is insufficient data on the pollutant releases of technologies in Australia to conduct a complete life cycle assessment of each technology option and much of the data used for the LCA is sourced from overseas. Pollutant inventory data has been sourced from published and unpublished literature (unpublished data sources include research results and inventory data from the Oko Institute and ITU GmbH and the CRC for Waste Management and Pollution Control). For this assessment, both primary data (data acquired by direct monitoring of the technology and associated system) and secondary data (data acquired through published literature and reports) are used. The data have been verified and reviewed as part of the data selection process. Where significant, the assumptions made in calculating the pollutant load per tonne of MSW are included.

2.1.4 Technology Configurations

The different treatment technologies reviewed are considered to be of a similar level of "best practice" with process waste treatment equipment configured to comply with the most stringent environmental regulations in the world.

The technologies under consideration include:

- Landfill;
- Conventional Incineration (with energy recovery);
- New Thermal Treatment (gasification & pyrolysis):
- Aerobic Processing (Mechanical Biological Treatment - MBT); and
- Anaerobic Digestion.

System configurations include:

Landfill – Independently validated Australian LCA landfill data is not yet available and overseas data has been used. As the landfill management standard is higher than for most landfills in regional Australia, the influence of this data limitation on final results is that the benefits of landfill avoidance are likely to be underestimated. The landfill system includes two staged leachate treatment of 1) biological treatment; and 2) chemical physical treatment. The biological treatment involves two phases. Leachate is first treated in a settling pond and then nitrification / denitrification proceeds through aeration. During chemical and physical treatment, pollutants are adsorbed to activated carbon and finally flocculation takes place using ferric compounds. The sludge is then dewatered and landfilled.

Gas flaring and combustion during energy generation proceeds in accordance with minimum specifications.

Mechanical separation - For the purpose of the study, it is assumed that alternative technology providers are required to recover dry recyclable materials at the yield levels achieved by the current recycling system in Townsville for plastic and ferrous and non ferrous metals. It is assumed that no paper or glass is mechanically recovered for recycling.

Biological Pre-treatment - Biological Pre-treatment involves the splitting of waste fractions according to particle size for biological pre-treatment. (Fines of less than 40mm in diameter are treated). The landfilling of remaining stabilised oversize assumes only partial mineralisation of carbon and with leachate and gas treatment equal to that of the landfill system described above. No physical load is associated with the application of compost to soils for this assessment while improved data would no doubt reveal a pollutant flux.

Mechanical Pre-treatment - Thermal processes may involve mechanical pre-treatment which is the splitting of waste fractions prior to combustion to obtain a high calorific value and homogenous fuel for combustion. This involves landfilling of the residual fraction and the inclusion of landfill impacts in the system model.

Conventional Incineration - Conventional incineration is assumed to take place at 900 degrees Centigrade with gas passing to the post combustion chamber prior to treatment. Treatment includes deNOx followed by energy recovery and treatment of dioxins and mercury using activated carbon. The flue gas passes through a fabric filter, 3 staged wet scrubber and wet electrostatic precipitation.

Gasification / pyrolysis - The gasification / pyrolysis process involves pre-treatment in a press at 1000 t pressure with pyrolysis proceeding at 600 degrees Centigrade for a retention time of 2 hours. Pyrolysed solids and raw synthetic gas are passed to a high temperature chamber first with unrestricted oxygen and then restricted oxygen to enable reduction of compounds. The synthetic gas is used in a gas motor. Gas cleaning includes: sour gas scrubbing, alkaline scrubbing activated carbon filter

2.1.5 Life Cycle Inventory Data

Life cycle data analysis involves a vast quantity of pollutant load data for each processing stage within the technology system under study. The pollutant loads are calculated per tonne of waste and recorded in a pollutant inventory. Life cycle data is applied for the air and water emissions from the tables below.

2.1.6 Life Cycle Impact Assessment

The emissions from processes may be aggregated and transformed into meaningful environmental impacts by using equivalence factors developed for Life Cycle Assessment.

To compare the environmental impacts of the recycling and alternative waste treatment options, the following environmental performance categories are assessed:

- Toxicity Assessment for Air Emissions;
- Toxicity Assessment for Water Emissions;

- Resource credits; and
- Global Warming Potential;

a) Toxicity Assessment

To facilitate the interpretation of the LCA data for air and water pollution, the "critical volumes" method has been used. This enables data aggregation into a meaningful indicator of chemical toxicity.

This approach relies on the regulated "permissible concentration" of pollutants to air and water and asks, "how much air (or water) is required to dilute the pollutant load to an acceptable concentration?" This volume of air (water) then becomes a standard unit for measuring the impact of the pollutant loads for the range of pollutants monitored. It is summed across all pollutant groups and a comparable total is provided for each technology. The load per tonne of "critical air" and "critical water" volumes is then presented.

Water – Pollutant Loads and Environmental Impacts

The German standard for permissible concentrations of pollutants in water is used to calculate the quantity of water required to dilute pollutant loads in the inventory to meet the acceptable concentration limit.

For example the German standard for the permissible concentration of Arsenic in water[4] is 35 ug/l. Over the life of a landfill, 27.5 mg/t of Arsenic is released to the environment through groundwater emissions and via sewage treatment. The water required to dilute this pollution to the standard is 785 litres.

Water pollutants are assessed in two categories:

- Water Pollutants (general)
- Water Pollutants (toxic).

The category of Water Pollutants (general) includes:

  - Cl (Chloride)
  - S (sulphate)
  - Ammonia
  - Nitrate

The category of Water Pollutants (toxic) includes:

  - Arsenic
  - Lead
  - Cadmium

[4] (compares with Average Daily Intake value of 2ug/kg body weight, NHMRC)

- Chromium
- Nickel
- Mercury
- Dioxin

Air - Pollutant Loads and Environmental Impacts

The pollutant load per tonne is presented below as the “critical air” volume.

The standards for permissible concentrations of pollutants in air are taken primarily from the NSW EPA (Clean Air Regulation). Where standards do not exist, the permissible standard is taken from the German standard to determine the critical volume of air required to dilute the emissions to an acceptable level.

Only general air pollutants are reported on. These include:

- Chlorine (HCl)
- Fluorine (HF)
- Sulphur dioxide
- Hydrogen sulphide
- Carbon monoxide
- Oxides of nitrogen

Global Warming Potential

The emission of pollutants with global warming potential leads to increased absorption of radiation energy in the atmosphere and consequently to an increase in temperature. This is referred to as global warming. Global Warming Potentials (GWPs) adopted by the National Greenhouse Gas Committee (1997) are used to weight the contribution of different chemicals to global warming on a CO2 equivalent basis (CO_2 emission equivalents in kg/tonne). Contribution to global warming is assessed by multiplying each substance’s emission to air by their GWP and summing over the total number of global warming contributors.

Substances included are:

- carbon dioxide
- methane
- nitrogen oxides

The greenhouse gas releases from conventional electricity production become the credits from the system when energy is recovered from waste. This data assumes a life cycle, fossil fuel mix of coal (82%), crude oil (14%) and natural gas (2.5%). As a result of this energy generation, greenhouse gases are released including: carbon dioxide (254 g / MJ) and methane (4.96 mg / MJ). In the calculations, methane assumes a CO2 equivalence factor or 21.

Resource Credits

Resource credits may arise from the production of energy, compost or other beneficial products from the waste system. For the recycling system, the resource credits include the avoided use of raw materials and energy. Resource credits relate only to the non-chemical stressor impacts associated with a system as emission credits are automatically included in the life cycle inventory system.

Resource credits are allocated an ecological, monetary value based on existing data. In this way a common unit can be provided for the resource value of, for example, one tonne of coal and one tonne of compost.

The ecological, monetary value used for compost is conservative and excludes any benefit that may be derived from increasing the yield of crops. The value used gives regard to soil degradation benefits of salinity, erosion, soil structure decline and water retention. The conservative value used is $36.30/tonne compost.

Raw material ecological values are taken from previous analysis performed for the Independent Assessment of Kerbside Recycling in Australia (Nolan-ITU, 2001). These include a value for coal of $47.50 per tonne. This value is derived based on current stock depletion rates and the physical land impact of mining activities. A similar derivation is used for bauxite, sand, crude oil, limestone and iron ore. These resources are credits associated with the recycling systems.

3 FINDINGS

The comparison of alternative waste treatment options with the current and improved recycling services for Townsville is conducted by impact category. It is important to note that all environmental calculations are based on the marginal benefit over landfill only. The benefit includes avoided landfill impacts.

3.1 Air Pollution

The provision of a recycling service delivers significant air pollution benefits. As illustrated in Figure 3.1, the treatment of waste by alternative treatment technologies also has the ability to provide substantial air pollution benefits.

For the treatment options of aerobic, anaerobic and new thermal treatment, the benefits are more than twice the benefits from the current recycling system.

NB: The analysis is specific to the type of configuration used for alternative technologies. The performance of thermal processes in particular is highly dependent on the type of gas cleaning equipment employed and other technical parameters.

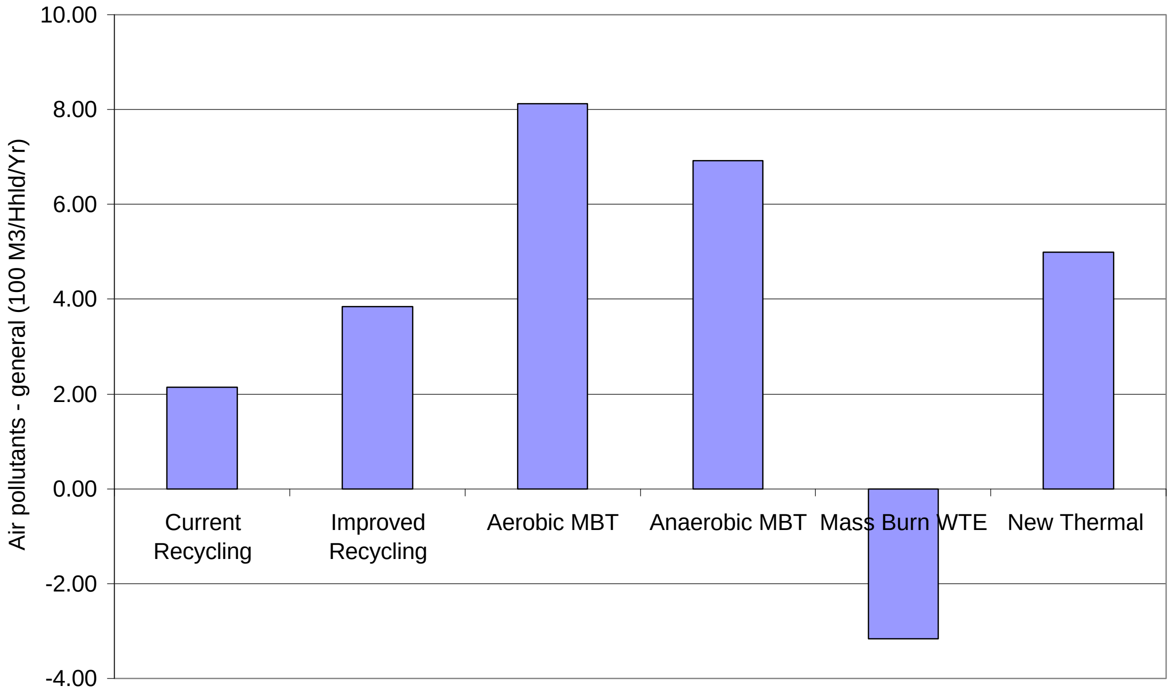

Figure 3.1: Air Pollution - Marginal benefit over landfill (100m3/hhld/yr

3.2 Water Pollution

Water pollution impacts from the adoption of alternative waste treatment technologies provide residents with a greater benefit than the available recycling services. The water pollution saving is dramatic and due largely to avoided landfill impacts.

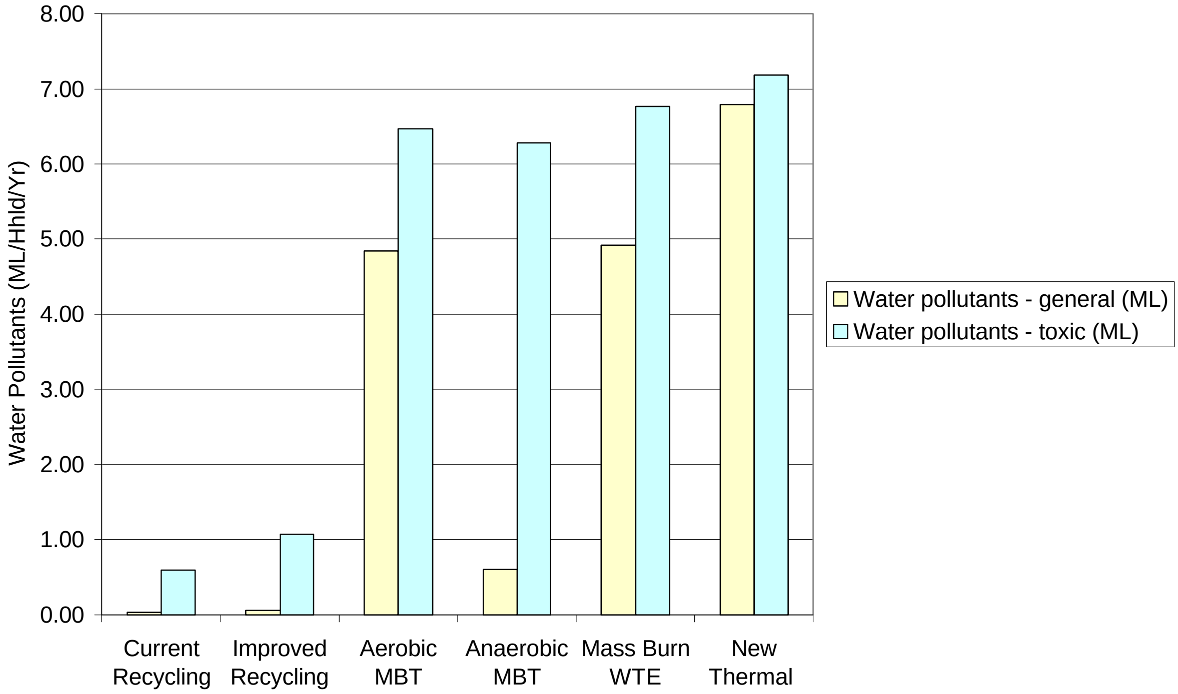

Figure 3.2: Water Pollution - Marginal Benefit over Landfill (ML/Hhld/Yr)

3.3 Global Warming Potential

A notable reduction in global warming potential is provided by the adoption of alternative treatment technologies. Most of the emission reduction is from avoided landfilling and the subsequent reduction in methane generation and release. In addition, credits are produced from electricity generation or from avoided production processes associated with resource recovery such as compost production or recycled material use.

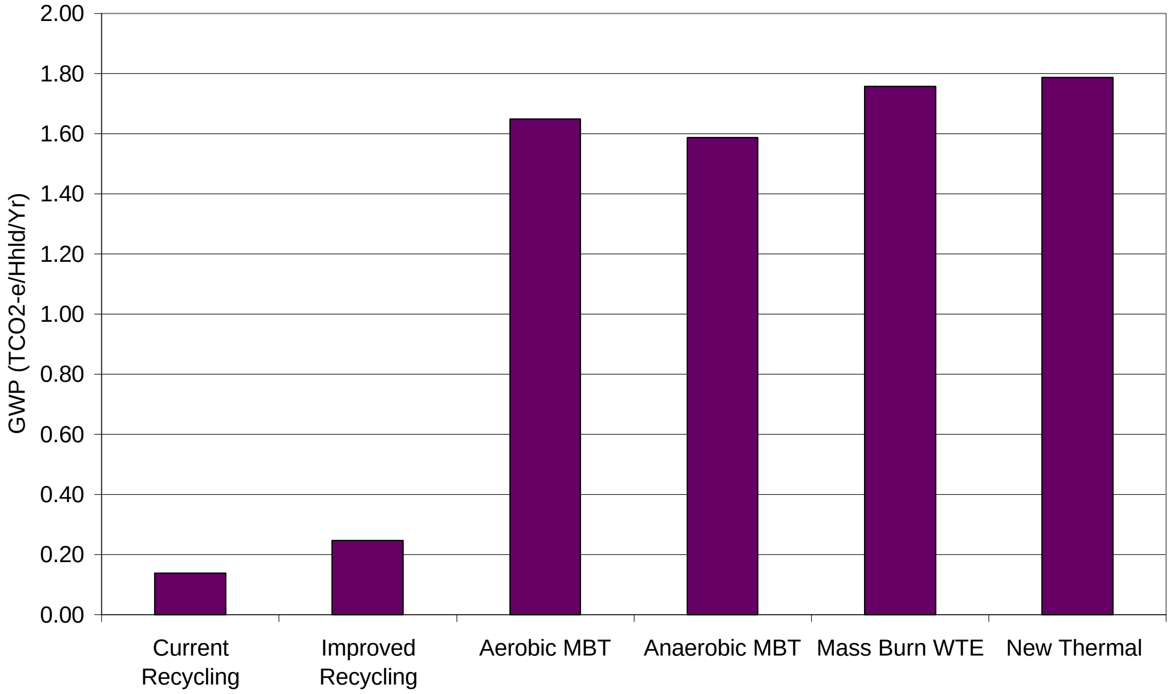

Figure 3.3: Global Warming - Marginal benefit over landfill (TCO2-e/Hhld/Yr)

3.4 Resource Credits

Resource credits are calculated for the recycling service and alternative technologies over the landfill only option. Only the resource credits for the aerobic MBT pretreatment technology exceed the resource credit benefit for the current recycling system.

The electricity credit from technologies does not result in a vast saving in terms of coal. The conversion of waste to electricity is an inefficient process in comparison with other fuel types and conversion technologies. Furthermore, the landfill only option also generated energy. This is credited to the system for the landfill life of 100 years. In contrast, the production of compost delivers benefits associated with avoided soil degradation, including benefits associated with salinity, acidification, soil structure decline and water retention. For this assessment a conservative value is used which excluded crop yield improvements.

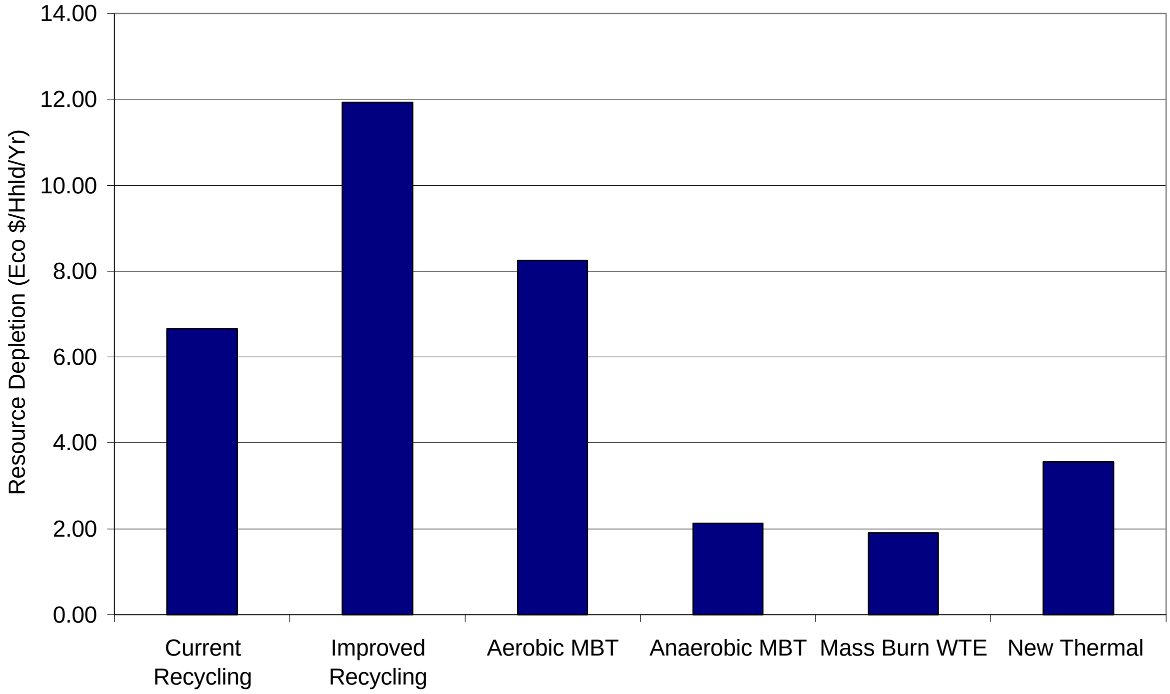

Figure 3.4: Resource Credits - Marginal Benefit over Landfill (Eco $/Hhld/Yr)

4 CONCLUSION

In general, the current recycling system, the improved recycling system and all four alternative waste treatment technologies ie., aerobic MBT, anaerobic MBT, conventional incineration with energy recovery and new thermal processes, offer significant environmental benefits over conventional landfilling of waste with no resource recovery . This is particularly the case for water pollution impacts and global warming potential, assuming recovery rates for the processing technologies for metals and plastics similar to current recycling system levels. The notable exception is the air impacts associated with conventional incineration where the environmental impact is negative in comparison with straight landfill disposal.

In terms of resource credits however, an improved recycling system would significantly outperform the alternative technologies, particularly in the case of anaerobic MBT, conventional incineration and new thermal technologies. Coupled with some form of resource recovery to achieve similar levels of metals and plastics recovery levels to the current recycling system, aerobic MBT would appear to offer increased environmental benefits, though at an increased financial cost to the community.

It should be noted, however, that alternative waste treatment technologies generally form part of an integrated waste management system. It is unlikely, for example, that all solid waste from the City of Townsville could be accommodated by one technology alone, as some waste streams would not be amenable to processing and either would requiring some other form of processing or disposal to landfill. Likewise there are likely to be residues from the processing that would require disposal to landfill.

In terms of waste management, the most favourable environmental outcome for Townsville and surrounding regions is likely to be delivered by an integrated waste management system that incorporates an improved recycling service for used packaging materials, combined with an aerobic treatment system for residual waste and a landfill to dispose of inert residues. As indicated in our previous letter (Ref: 4081 01, TCC Fin Rpt 1.1), there are significant costs associated with providing such a system and Council would need to balance these costs against the environmental benefits gained and the expectations of the community.