Final Report

Recycling: Cost Benefit Analysis

Prepared for

Ministry for the Environment

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Executive Summary

Waste minimisation—processes to minimise the quantity of material that requires final disposal— is encouraged in New Zealand through policies and programmes at national, regional and local levels. This has included the establishment of targets for recycling of individual materials.

This study examines the costs and benefits of recycling to address the following questions:

- What are the economic costs and benefits of diverting a number of waste streams from current disposal practices?
- What is the net economic effect of given levels of recovery of each of these wastes? ie how do the costs and benefits compare?
- Are there opportunities for net economic benefits from increased levels of diversion of individual waste streams?

The study is not comprehensive of all waste streams but assesses the costs and benefits of recycling some of the more important materials by volume. These are:

- paper
- plastics
- glass
- organic waste (kitchen waste and greenwaste)
- construction and demolition waste
- tyres
- used oil.

In addition, the report does not consider the costs and benefits of all waste management options. Rather, it compares the costs and benefits of recycling, and particularly household kerbside recycling, relative to landfill disposal. Other options include waste reduction measures that limit waste at source and alternative approaches to collection of materials for recycling, including through deposit refund schemes or bring systems. This wider level of analysis is beyond the scope of this work. Also excluded is direct business-to-business recycling for which few data are available.

Element of Analysis

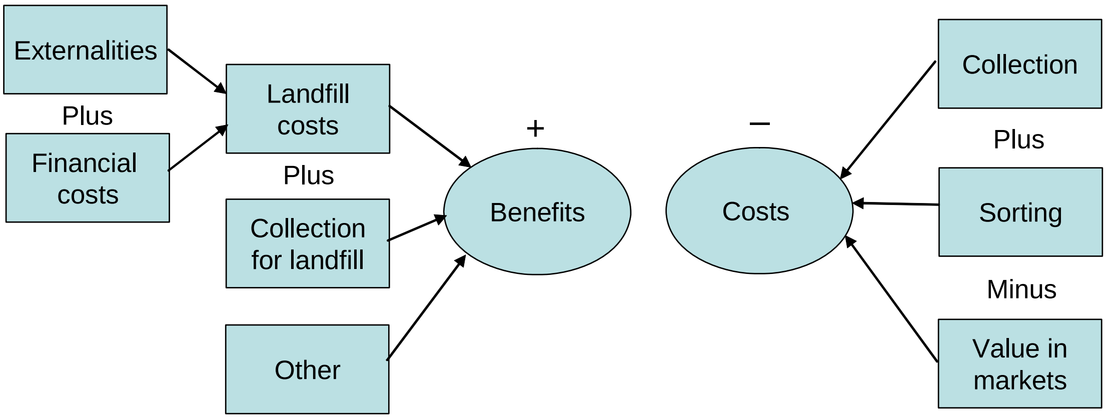
The components of the analysis are shown in the figure below. The benefits of recycling are estimated from:

- savings in landfill costs which are made up of the financial costs of landfill and externalities (environmental costs)

- the saved costs of collection for disposal

- other benefits, including 'direct consumer benefits' which are a measure of the extent of people's personal preferences to recycle rather than create waste. Direct consumer benefits are expressed as the difference between people's willingness to pay to recycle and the actual cost.

Components of the analysis



Costs of recycling are estimated from the costs of collection and sorting, less the value of material in end-use markets.

The analysis for each material uses three sets of assumptions:

- an initial rate of recycling based on benefit estimates that include savings in landfill costs (using the social cost estimate rather than a market rate) but ignore the external costs associated with emissions, leachate and the direct consumer benefits
- a low-benefit estimate that uses low estimates of external benefits of recycling
- a high-benefit estimate that uses high estimates of external benefits of recycling.

The results are summarised in the table below. It shows the percentage of materials that are assumed to be technically recoverable using current technologies, the percentage currently recovered and percentages that could be recycled for each material with positive net benefits under high and low benefit assumptions. It shows the results using two discount rates: 5% and 10%.

The analysis suggests that there is the potential to increase rates of recycling at a positive net benefit for nearly all waste streams. The only exceptions to this are PVC, LDPE and organics for which, under low benefit estimates, the results suggest that recycling rates are currently higher than optimal. For organics, it should be noted that the analysis of costs assumes a different collection methodology from that used currently. Specifically, the analysis assumes that kerbside collection of organic material is used rather than the current drop-off system. Therefore the results cannot be used to conclude that current rates of recycling of organics are too high, but rather that switching to the different collection method is justified only under the high benefit value assumptions.

Clear glass shows net benefits of collecting close to current rates, although the estimates of current rates ignore the fact that considerable quantities are being stockpiled awaiting the identification of suitable markets. The analysis here suggests it is worthwhile collecting some of this material for low (zero) value markets.

The contributing factors to the net benefits vary by material, but where they are included (household waste, including organics, end-of-life tyres and used oil), direct consumer benefits, estimated from a willingness to pay study undertaken in parallel with this study, are the most significant contributing factor to total benefits. These are potentially the most contentious elements of the analysis partly because, to our knowledge, such estimates have not been included in other recycling cost benefit analyses. However, the legitimacy of this benefit seems clear.

Summary of Results— Recoverable, currently recovered and quantities that could be recycled with positive net benefits (%)

	Technically recoverable	Currently Recovered	Low Benefit Values		High Benefit Values	
			10% d.r.	5% d.r.	10% d.r.	5% d.r.
	%	%	%	%	%	%
Paper – household	75	67	75	75	75	75
Paper – commercial	75	51	75	75	75	75
Plastic - PET	58	16	58	58	58	58
Plastic – HDPE	58	16	58	58	58	58
Plastic – PVC	58	16	0	0	58	58
Plastic - LDPE	58	16	0	0	58	58
Glass- Coloured	85	50	63	64	85	85
Glass -Clear	85	50	47	50	85	85
Steel	85	51	85	85	85	85
Aluminium	85	51	85	85	85	85
Organics	85	34	7	9	85	85
Tyres	80	0	78	78	80	80
Used Oil	100	60	100	100	100	100
Concrete	80	35	58	58	62	62
Timber	80	35	80	80	80	80
Total	80	38	58	59	75	75

d.r. = discount rate

Willingness to pay studies can over-estimate benefits because people can over-state their willingness to pay when they do not believe that they will actually have to pay or they do not fully understand the payment mechanism. This is tackled to some extent through the inclusion of questions about willingness to spend time in addition to willingness to pay financially. However, there remains a degree of uncertainty regarding the size of these benefit estimates. This is also because there is uncertainty over whether the respondents assumed that their willingness to spend time related to the current quantity of material collected, or to an increased volume, for which there would be a requirement for additional time to be spent. The range of values used takes account of this uncertainty and the values are still sufficiently high to provide significant additional benefits of recycling. There would be value in further research into the willingness to pay values to better understand the assumptions being made by households.

Taking the full set of benefits into account, the results suggest that increasing rates of recycling in New Zealand is justified across all assumptions, for the majority of materials examined. Consistent with this, least cost instruments to achieve higher rates of recycling should be examined.

1. Introduction

1.1. Background and Objectives

Waste minimisation—processes to minimise the quantity of material that requires final disposal— is encouraged in New Zealand through policies and programmes at national, regional and local levels. This has included the establishment of targets for recycling of individual materials.

Government intervention to encourage waste minimisation is justified on the basis of market failure. In the national waste strategy, examples of market failure are used to define the waste problem; these include the environmental effects of landfill and inefficient resource use.[1] In this report we examine the nature of the externalities and other market failures; we combine these impacts with other costs and benefits of recycling to address the following questions:

- What are the economic costs and benefits of diverting a number of waste streams from current disposal practices?
- What is the net economic effect of given levels of recovery of each of these wastes? ie how do the costs and benefits compare?
- Are there opportunities for net economic benefits from increased levels of diversion of individual waste streams?

1.2. Scope

The study is not comprehensive of all waste streams but assesses the costs and benefits of recycling some of the more important materials by volume. These are:

- paper
- plastics
- glass
- organic waste (kitchen waste and greenwaste)
- construction and demolition waste
- tyres
- used oil.

In addition, the report does not consider the costs and benefits of all waste management options. Rather, it compares the costs and benefits of recycling, and particularly household kerbside recycling, relative to landfill disposal. Other options include waste reduction measures that limit waste at source and alternative approaches to collection of materials for recycling, including through deposit refund schemes or bring systems. This wider level of analysis is beyond the scope of this work. Also excluded is direct business-to-business recycling for which few data are available. In any case, this is not

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[1] Ministry for the Environment (2002) The New Zealand Waste Strategy: Towards zero waste and a sustainable New Zealand

part of the problem and these quantities are not included in existing landfill waste data, but it is noted that this means recycling levels are likely to be under-estimated.

1.3. Report Format

The report covers in turn:

- general issues to do with the approach to analysis, including the assumptions underlying cost benefit analysis (Section 2)
- the waste, landfill and recycling data used as inputs to the analysis (Section 3)
- the estimated benefits of recycling associated with reduced waste collection and landfill costs, the externalities associated with landfill and the direct benefits to consumers from recycling (Section 4)
- the size and value of markets for materials collected for recycling (Section 5)
- the costs of recycling including collection and treatment (Section 6)
- the net benefits of recycling, weighing up the costs and the benefits (Section 7)
- overall conclusions are made in Section 8.

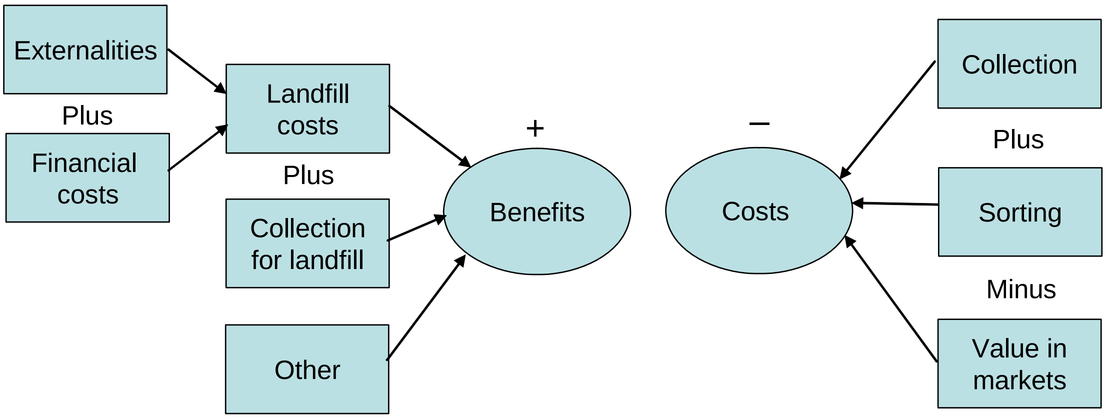
2. Approach to analysis

2.1. Components of the cost benefit analysis

The components of the analysis are shown in Figure 1. The benefits of recycling are estimated from:

- savings in landfill costs which are made up of the financial costs of landfill and externalities (environmental costs);
- the saved costs of collection for disposal;
- possible other benefits—amongst other things, we examine possible direct consumer benefits that are expressed as the difference between a willingness to pay to recycle and the actual cost.

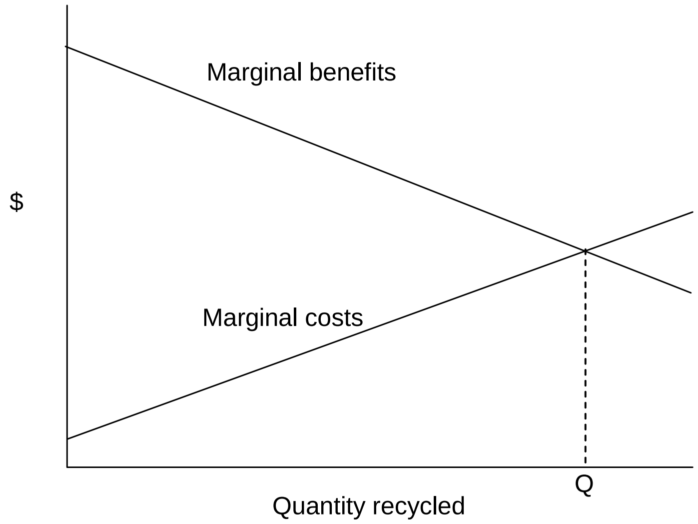
Figure 1 Components of the analysis



Costs of recycling are estimated from the costs of collection and sorting, less the value of material in end-use markets.

The data are analysed to build up cost and benefit curves for individual materials such as illustrated in Figure 2. The analysis takes a marginal perspective, ie it measures the costs and benefits of additional levels of recycling; this allows an assessment of the optimal quantity of recycling. As is discussed in the following pages (Section 2.1.4), a key requirement for such an analysis is to build up a sloping “curve” rather than a horizontal line based on a single cost or benefit estimate. The slope or steps on the marginal cost and benefit curves are built up through assessing costs and benefits for separate geographical locations—Territorial Local Authority (TA) areas.

Figure 2 Costs and benefits of recycling



2.1.1. Assumptions Underlying Cost Benefit Analysis

Cost benefit analysis brings a set of assumptions, some of which are usefully outlined in more detail.

The starting point for cost benefit analysis of government policies is the assumed objective: policy should result in an improvement in the overall welfare or well-being of society. To assess this, cost benefit analysis measures total costs and benefits wherever they fall in society and compares one with another; wellbeing-improving projects or policies are those for which the total benefits exceed the total costs. In doing this, analysis is not concerned with whether projects or policies have effects that differ across society, for example, if a decision has a net benefit for the nation but results in net negative impacts on some people and net positive impacts on others. The theory is that aggregate distributional effects of many individual policies (or the absence of policy) are addressed in aggregate, rather than for each individual policy.[2]

Cost benefit analysis uses money as a way of aggregating overall impacts on wellbeing. It assumes that the way that people spend their time and money reflects their underlying preferences and that all individuals are seeking to maximise their wellbeing. Thus decisions to recycle or not are based on a weighing up of the personal costs and benefits of those decisions. Within this, individuals will state their preferences for living in a less wasteful society or for other outcomes that might result in a willingness to recycle, for example, through their willingness to spend time on these activities. Firms are assumed to act consistently with maximising their wellbeing, expressed as profit.

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[2] The theory is that a project that has net benefits would allow the winners to compensate the losers and for the winners still to have a surplus. But it does not matter that the winners do not actually compensate the losers, just that they could have done. Whether compensation should be paid is a separate decision. In addition, the net impact of many projects and policies is that losers from one policy may be winners of another and the net effect may balance out over time. This leaves the government the choice of whether to compensate net losers after many projects and policies.

The environment is treated in the same way as other resources, ie no consideration is given to any differences between the impacts on natural and physical capital. Rather it is assumed that people's preferences for attributes of the environment (including reduced impacts of waste) can be expressed in the same way as can their preferences for other items, like fast foods, time and fizzy drinks.

Cost benefit analysis assumes that people and firms act consistently and rationally with the objective of maximising wellbeing and that we can use money as a convenient way of measuring the aggregate effects on wellbeing.

2.1.2. Other potential benefits

In addition to the financial value of recovered materials and savings in environmental externalities, there are two other types of potential benefit that are considered: direct consumer benefits and the impacts on New Zealand's image.

Direct Consumer Benefits

The motivation for individuals to recycle is not always clear. Where households or industry pay per unit output of waste, there is a financial incentive to recycle if this is a lower cost than the disposal alternative. However, many households recycle when there is no private financial incentive. This might be when they do not pay per unit of waste output or the amount they pay is sufficiently lumpy that it does not change with reduced volumes of waste output. For example, this might be households putting out one or two bags per week or who use a bin with excess capacity. In these circumstances, the motivation for recycling must be related to some other personal benefits or a sense of communal or personal responsibility.

A UK study of attitudes to recycling found that low or non-recyclers felt that recycling was not an important enough issue to most of them, but many of them thought of it as a 'good thing' to do, and hence felt guilty for not doing it. In contrast, medium/high recyclers were often motivated by a 'feel good' factor.[3] It is likely that motivations are a mixture of intrinsic satisfaction and avoidance of guilt about not recycling. We do not attempt to analyse these motivations further, but simply to acknowledge that there is a consumer benefit associated with recycling and a disbenefit from not recycling. This study includes the results of a survey of households that has been used to place a value on these consumer benefits.

The effects of including these benefits are considerable and it raises the obvious question of whether these are additive. For instance, if households are willing to recycle because they perceive that this will reduce volumes going to landfill and improve resource efficiency, can their consumer surplus (the difference between their willingness to pay and current costs of recycling) be added to the other benefits of recycling which take account of the external costs of landfill and where steps are being taken in other

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[3] Thomas C, Slater R, Yoxon M, Leaman J and Downing P (2003) What Makes People Recycle? An Evaluation of Attitudes and Behaviour in London Western Riverside. Paper presented at the ISWA World Congress 2003. http://oro.open.ac.uk/3976/01/What_makes_people_recycle_C.Thomas.pdf

markets, through other regulations, to tackle externalities of resource use? In other words, is there a benefit that households are receiving that is not accounted for elsewhere? Our view is that there is.

Regardless of the landfill charges that are paid (by someone) and the value of recycled materials, householders appear to be willing to spend time and money on recycling activity. A counter-argument might be raised if it is thought that households are unaware of the costs of landfill and the extent to which externalities are covered either for landfill or for other resources. The argument could be raised that if they were aware, the time (or money) they are willing to spend on recycling would reduce. This is uncertain—we have no way to test this in the absence of a more detailed survey that also ascertained the state of current knowledge of households. However, we suggest that this may not make a difference and that households are obtaining an intrinsic benefit from recycling that relates to factors not currently charged for and not accounted for in other elements of the benefit analysis.

Impacts on New Zealand's Image

The Ministry for the Environment has suggested that the existence of recycling schemes may be a contributing factor to the "clean green image" by which New Zealand seeks to portray itself. This objective was set out recently by the Prime Minister, in a statement that linked improved waste management with goals of environmental sustainability, in turn a part of sustaining New Zealand's unique culture, values, and national identity in a world of globalised media and culture.[4] In this context, the concern is that international perceptions of New Zealand will be affected by rates of recycling.

Research undertaken for MfE identified the impacts of worsened environmental perceptions on exports of dairy products, organics and on inbound tourism;[5] it found significant value of protecting the image[6] but the research cannot be used to identify the impacts of changes in individual components, eg loss of recycling activity, let alone changes in volumes recycled.

For analysis here, the changes that need to be examined are marginal, ie the analysis is of the impacts of changes in the total volume of material recycled rather than impacts of recycling per se. There are too many uncertainties to include these effects in analysis. These uncertainties include:

- whether national image is affected by changes at the margin, eg additional tonnes of plastics recycled versus simply that plastic is recycled;

- what is the margin? It might be more tonnes collected in existing schemes or extension of collection to areas not currently covered.

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[4] Prime Minister's Statement to Parliament, February 13th 2007. (www.beehive.govt.nz)

[5] PA Consulting (2001) Valuing New Zealand's Clean Green Image.

[6] PA Consulting estimated the impacts as up to a $569 million loss in revenue (and $61 million lost profit) in the dairy industry and a loss of up to $938 million for inbound tourism measured as direct value added, employment and GST.

We ignore these impacts in analysis, while recognising that there may be some additional value

Employment Impacts

Employment effects are sometimes discussed as benefits and sometimes as costs. In cost benefit analysis labour is treated as a cost. So if more recycling leads to more jobs this is measured as an increase in labour costs. This is an opportunity cost approach and is consistent with the treatment of all other costs in the analysis. It is assumed that wage rates reflect the value of this labour in other markets. In other words, by employing people in recycling, there is a lost opportunity for them to work in another industry in which they would be productive, add value and in which another employer would be willing to pay them.

When unemployment rates are high, the opportunity cost of labour will be low. This is because there is a large pool of labour that is not being used for other productive uses. In a completely unregulated market (eg with no minimum wage legislation and no unemployment benefit), high unemployment would be reflected in low wage rates. New Zealand has a labour market with some regulation; it means that wage rates do not drop to very low levels in times of significant unemployment. However, analysis can take account of the low opportunity cost of labour by using 'shadow' labour costs that involve a reduction from market wage rates to low levels, or even zero. This tries to mimic what the market wage rate would be in the absence of regulation. Labour costs might be measured at less than zero (ie a benefit of employment) if there were positive externalities from employment (or negative externalities of unemployment) which would mean that society was willing to pay to reduce unemployment. However, because unemployment rates are currently low[7] it is reasonable to assume that wage rates are a good proxy for the opportunity cost of labour. Labour is treated as a cost equal to the appropriate wage rate in the analysis.

2.1.3. Elasticity of Diversion/Fly Tipping

Fly tipping involves the unauthorised disposal of waste which may be on private or public land. It has costs because of the amenity impacts and/or the costs of removal to an authorised disposal facility. Recycling, or more specifically the policy instruments or other interventions used to achieve greater rates of recycling, can lead to increases or reductions in the level of fly tipping.

On the one hand, fly tipping occurs because it is lower cost than the alternative, ie authorised disposal. Where there is the option of recycling waste this may be lower cost than landfill disposal and thus can result in reduced fly tipping activity.

On the other hand, the mechanisms used to encourage greater levels of recycling may lead to higher costs of disposal, eg landfill levies that encourage recycling can result in increased levels of fly tipping. Although there is little empirical evidence of

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[7] At approximately 3.7%, New Zealand has the fourth lowest unemployment rates in the OECD (Department of Labour Household Labour Force Survey December 2006 http://www.dol.govt.nz/publications/lmr/lmr-HLFS.asp)

unauthorised tipping in response to increased landfill disposal prices or unit charging for collection and disposal, this does not suggest that it does not occur, just that it has been little studied. A recent OECD report had numerous references to the issue, for example, but these were largely theoretical and anecdotal.[8]

However, the issue and the direction of the effect apply to the policies used as opposed to the targets adopted or the level of recycling per se. In contrast, this report does not analyse the policies used to achieve higher rates of recycling, just the costs of the technical choice. In addition, there are few data that could be used, either on the costs or the elasticity of response to landfill changes. Fly tipping impacts are not included in the analysis in this study.

2.1.4. Marginal Cost Analysis

The study examines the marginal costs and benefits of recycling. That is, the analysis is focused on changes to quantities recycled—the costs and benefits associated with recycling one more tonne of a given material. This is the appropriate form of analysis when examining the appropriate level of recycling to achieve. In contrast, total or average costs of recycling would be examined if simply analysing whether a specific recycling project should go ahead.

Marginal analysis can be undertaken over the long or short run. In the short run, not all costs and benefits are relevant. For example, there will be a range of fixed costs associated with a Materials Recovery Facility (MRF) that will not change with quantities of throughput. This is not always straightforward, as it depends to an extent on scale. Thus a small change in volume recycled will not require a change in the number of collection trucks that will be associated with a more significant change in volume. It also depends on how the margin is defined—is more collected in an existing recycling scheme or is recycling extended to areas that do not currently have a recycling system?

We have used average costs of recycling, which is closest to a long run marginal cost (LRMC) estimate. This is consistent with an analysis concerned with significant changes in recycling volumes and/or marginal changes that are based on extending recycling to areas that currently are not covered by recycling schemes.

On the benefit side, savings in landfill costs are estimated using an LRMC approach. This measures the saved costs associated with future landfills on the basis that this is the opportunity cost of using up space in existing landfills.

2.2. Level of Analysis

The variation in costs and benefits that allow optimal levels of recycling to be defined require that analysis is undertaken at a sufficiently disaggregated level so that differences in costs and benefits can be identified. Without disaggregation, analysis may simply provide information to address a binary decision: is recycling beneficial or not? This is because, for any given material, the analysis using existing data may provide a

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[8] OECD (2004) Addressing the Economics of Waste.

single point estimate of the costs and a single point estimate of benefits—this is of limited usefulness. However, costs and benefits are likely to vary geographically, eg by individual landfills and collection/recycling schemes.

The approach adopted has been used to achieve sufficient disaggregation so that cost differences arise, but that makes the study manageable within the time and budget allowed. The analysis has used Territorial Local Authority (TA) data on waste arisings and developed an assessment of costs and benefits at this level. This has included the identification of site specific costs based on population density and the location of markets so that transport costs to market can be calculated.

2.3. Limitations

2.3.1. Data

The analysis is limited by the data available. The time for this study has not allowed for much collection of primary data. Rather it has used existing data sets in the main, including those available to the Ministry for the Environment (MfE), the consultants and published reports. In parallel with the cost benefit work, a willingness to pay survey was conducted amongst households to identify direct consumer benefits of recycling and additional information on costs and revenues for collected materials were obtained from meetings and phone interviews with relevant industries.

Covec was assisted in its estimation of costs and revenues by Morrison Low & Associates (MLA); it provided data and reviewed collected data and assumptions made.

2.3.2. Full lifecycle benefits

The study is not able, in the time available, to examine the full lifecycle benefits of recycling options. The analysis includes the external costs of landfill on the basis that this is a major element of missing costs. This is compared to the financial costs and benefits of recycling. It is frequently argued that recycling has wider benefits associated with reduced use of raw materials and energy, and that these are currently under-priced in the market. For example, if recycling involves reduced use of energy compared to use of virgin raw materials and energy prices do not include the costs of emissions (which they do not currently), then there is some additional value associated with recycling. However, this involves a life cycle analysis that is specific to the manufacture of individual products; this is beyond the potential scope of this study in the time and budget constraints. Rather the assumption will be made that market prices reflect the full social value of these alternatives to manufacture from virgin raw materials.

There is an additional consideration here which is that many of these potential additional market failures are being tackled through other policy interventions and that these are likely to be more appropriate. For example, if there are benefits from energy savings associated with glass recycling and that these are greater than the market value of energy savings, eg because of underpricing of energy and/or associated greenhouse gas emissions, then these should best be tackled through energy and climate change policies rather than via waste policy.

The Australian Productivity Commission states that "Any case for using waste policy to address upstream externalities would have to be very carefully evaluated and be based on an inability to effectively use more direct policies. It should not be presumed that governments do not intervene upstream… The Commission considers that … it is highly unlikely that a waste management policy would be the best way of tackling an upstream environmental externality".[9]

This statement makes sense as a driver for policy intervention and suggests that these benefits not be taken into account in justifying waste management policy.

However, not taking them into account might suggest a lower total level of recycling because the market would achieve a higher amount than it does currently if these upstream costs and benefits were internalised in market prices. For analysis we need to be clear on the implications. If the externalities of manufacture (of glass, steel, etc) were included in market prices, market-driven recycling rates would be likely to be greater, as would the estimated optimal levels of recycling. However, without including them it is still possible to address the question of whether waste management policy should be used to encourage greater rates of recycling than occurs currently.

2.4. Discount Rates

One of the key assumptions for the analysis of costs is the discount rate.

Private sector investors use discount rates as rationing devices for scarce capital and other resources. Discount rates are an opportunity cost concept; they are used to measure the implications of diverting resources into one set of activities (eg building a landfill, running a recycling centre) at the expense of another. The same approach is required for public sector decisions; introducing policy to ensure that certain outcomes are achieved diverts resources to where otherwise they would not be used. This has costs that are equal to the value of the resources if used elsewhere. Private sector decision makers measure a risk-weighted opportunity cost of capital. This takes account of rates of return in other investments but weights the investment for risk; these risks are associated with a range of factors that include movements in market prices.

Private and public sector discount rates are different because of differences in levels of risk and scarcity levels. Many of the risks that apply to private sector investors do not apply to the government as risks are spread across all members of society. And capital scarcity is less of an issue at the level of the nation. The approach taken is often to measure an opportunity cost of consumption—the effect of policy is to shift consumption levels over time, eg by spending time recycling we have to shift time spent on other activities into the future.

In the context of energy policy, the MED has recently undertaken an analysis of a discount rate for New Zealand based on an assessment of the opportunity cost of

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[9] Australian Government Productivity Commission (2006) Waste Management. Productivity Commission Inquiry Report No. 38. 20 October 2006.

consumption; it estimated a rate of 4.4% but believed that 5% was sufficiently close to be a useful rate for analysis.[10] However, the Treasury suggests that a 10% discount rate should be used in analysis in the absence of a rate developed for a specific sector.[11]

For analysis in this report, a 10% rate is used as the default value, but a 5% rate is used in sensitivity analysis.

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[10] MED (2006) Choice of Discount Rate for the New Zealand Energy Strategy (NZES) Briefing to the Minister of Energy 14 September 2006.

[11] New Zealand Treasury (2005) Cost Benefit Analysis Primer.

3. Waste Volumes

This section analyses total waste flows in New Zealand as used in analysis.

3.1. Waste Flows to Landfill

The amount of waste flow to landfill has been estimated using data in the *2002 Landfill Review and Audit* published by MfE.[12] This document contains data on annual landfill tonnage, by region, for 2001/2002. These quantities are then updated by applying regional population growth factors (Stats NZ), to obtain an estimate of approximately 3.25 million tonnes of waste being disposed to landfill in 2006 (Table 1).[13]

Table 1 Annual Waste to Landfill by region (2002)

	2002	2006 (Estimated)
Auckland	930,000	1,082,802
Bay of Plenty	151,000	158,535
Canterbury	340,000	359,794
Hawkes Bay/Gisborne	140,000	140,140
Manawatu/Wanganui	163,000	162,266
Nelson/Tasman/Marlborough	106,000	113,057
Northland	98,000	100,772
Otago	162,000	168,577
Southland	109,000	107,802
Taranaki	60,000	59,760
Waikato	237,000	246,133
Wellington	501,000	522,368
West Coast	25,000	24,825
Total	3,022,000	3,246,831

Source: Ministry for the Environment (2003) 2002 Landfill Review and Audit; Covec estimates

These regional estimates of waste tonnage to landfill are then disaggregated further to a TA level. The allocation is based on population estimates. In certain cases, where a TA straddles multiple regions, the waste estimate is allocated on the basis of the population of the TA contained within a specific region.

Estimates of the composition of waste to landfill are derived from surveys of disposal facilities reported by WasteNot Consulting (Table 2). We have applied these proportions to our estimated tonnage to obtain estimates for the tonnage of specific waste products going to landfills in 2006.

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[12] Ministry for the Environment (2003) 2002 Landfill Review and Audit.

[13] Currently unpublished landfill census data for 2006 estimate total waste going to landfill as 3.156 million tonnes in 2006.

Table 2 Composition of waste to landfill

Primary category	% of total
Paper	14.9%
Plastics	9.1%
Putrescibles	23.3%
Ferrous metals	5.1%
Non-ferrous metals	0.9%
Glass	2.5%
Textiles	3.9%
Nappies & sanitary	2.7%
Rubble, concrete,	12.2%
Timber	13.9%
Rubber	1.0%
Potentially hazardous	10.5%
TOTAL	100%

Source: WasteNot Consulting (2006) Waste composition and construction waste data. Prepared for the Ministry for the Environment

3.2. Waste Recycled

The annual tonnage of diverted waste is estimated by combining data on household recycling with data on business recycling.

The annual tonnage of household waste that is diverted is estimated from the data in the NZWS Targets TA Survey. The data in this survey includes estimates by the TAs of the amount of inorganic and organic waste diverted by them. The inorganic waste collected is then further broken down into separate waste product streams (Table 3).

Table 3 Proportion of waste products in diverted inorganic waste

Paper	Plastics	Ferrous Metals	Non-ferrous metals	Glass
60.0%	9.0%	3.7%	1.0%	26.2%

Source: New Zealand Packaging Accord 2005 Progress Report

The NZWS Targets TA Survey also contains data provided by the TAs about the amount of organic waste diverted. We use these data in our organic waste analysis. Using this approach, the estimates of household waste diverted are shown in Table 4.

Table 4 Household recyclable material quantities

	Generated (tonnes)	Recovered (tonnes)	Recovered (%)
Paper	299,625	200,893	67%
Plastic	42,303	30,114	71%
Metal	31,029	15,793	51%
Glass	127,841	71,069	56%
Organic	415,764	195,620	47%
Total - recyclables	916,563	513,489	56%

We have estimated the amount of annual diverted business waste from data provided by MfE for total waste diverted (Table 5) and subtracting the estimates of household waste diverted as calculated above. The resulting estimates of business waste diverted are shown in Table 6.

The difference between the above numbers and the estimated amount of diverted household waste (from the NZWS survey) for a specific product is then allocated to the TAs according to population.

Table 5 MfE's best estimate of materials diverted from landfill and cleanfill

Waste Stream	Amount Diverted (estimated tonnes)	Data Source
Glass	92,826	Packaging Accord Data 2005
Paper	454,212	New Zealand Paper and Packaging Association estimate for 2005
Plastics	39,100	Plastics New Zealand estimates for 2005
Scrap Metal	495-550,000	Scrap Metal Recycling Association annual estimates
Organics	312,085	Survey of TAs 2006
Construction and Demolition	1 million	Estimates from direct contact with construction and Demolition industry

Source: Ministry for the Environment

Table 6 Commercial recyclable material quantities

	Generated (tonnes)	Recovered (tonnes)	Recovered (%)
Paper	493,912	254,000	51%
Plastic	203,634	9,000	4%
Metal	621,130	500,000	80%
Glass	50,236	17,767	35%
Organic	501,530	116,465	23%
Total - recyclables	1,870,443	897,232	48%

3.3. Landfills

In 2002 there were an estimated 155 landfills accepting approximately three million tonnes of waste, but it is estimated that only 43 will remain by 2010 (Table 7). In 2002 only 20% had engineered containment whereas this was expected to increase to 67% of landfills by 2010. In 2002 only 83% of landfills measured the quantity of waste and 82% charged for it; these figures are expected to increase to 100% by 2010.[14]

With a reduction in the number of landfills, they are increasing in size. Approximately three million tonnes of waste going to 115 landfills (2002 data) results in an average rate of disposal of 26,000 tonnes. However recently-opened landfills include Hampton Downs, south east of Auckland that accepts 200,000 tonnes per year and Kate Valley near Christchurch, opened in 2005, that will take 300,000 tonnes per year.

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[14] Ministry for the Environment (2003) 2002 Landfill Review and Audit

Table 7 Total landfills

	2001/02		2005	2010	
Location	Number	Tonnes/yr	Number	Number	Number high standard
Auckland	6	930,000	3	3	1
Bay of Plenty	7	151,000	3	2	1
Canterbury	9	340,000	2	3	1
Hawke's Bay/Gisborne	4	140,000	3	5	1
Manawatu/Wanganui	13	163,000	10	4	1
Northland	4	98,000	4	2	1
Otago	13	162,000	11	6	0
Southland	13	109,000	13	1	1
Nelson/Tasman/Marlborough	4	106,000	4	3	0
Taranaki	6	60,000	2	1	1
Waikato	6	237,000	6	5	2
West Coast	20	25,000	8	4	0
Wellington	10	501,000	9	4	1
New Zealand	**115**	**3,022,000**	**78**	**43**	**11**

Source: Ministry for the Environment (2003) 2002 Landfill Review and Audit

For analysis, we have made assumptions both about the size and location of landfills so that transport costs can be estimated also (see Annex 1). The basis for the analysis is the 2010 projections of 43 landfills in total and the regional location of these. This was used to define the location of individual landfills and was combined with waste generation data to define the size of these landfills and thus their costs (see Section 4.3).

4. Benefits of Recycling

4.1. Components of Benefits

The benefits of recycling are comprised of:

- market values of the materials collected
- the avoided costs of collection and disposal
- avoided external costs of landfill disposal
- direct consumer benefits.

The market values are discussed separately in Section 5 below. The other components of value are discussed in turn below.

4.2. Avoided Costs of Collection for Landfill

The costs of collection of materials for landfill are saved when material is recycled. This is offset by the costs of collection for recycling, estimated in Section 6.

One of the key issues is the extent to which collection costs vary by location. We have used a generic assessment of costs but varied the total costs using the housing density of the different locations; this affects the distance per truck per day, households per truck and the tonnes per truck. The initial estimates for the city locations are given in Table 8.

Table 8 Waste collection cost assumptions

	Bag	Bin	All
Trucks			
Truck ($/truck)			225,000
Lifetime (years)			7
Tonnes/truck pa			3,750
Fixed costs ($/truck pa)			2,000
Households/truck			8,800
Bags/bins			
Box/bin ($/item)	0.12	36	
Lifetime (years)	0	7	
kg/household/week	7.5	15.0	
$/t	16	10	
Labour			
Driver ($/hour)	16	16	
Runner ($/hour)	14	14	
Runners/truck	2	1	
Labour/truck pa (40 hr week)	76,960	62,400	
Fuel			
l/100km			45
Distance per truck per day			111
Fuel price - diesel ($/litre)			1
Fuel ($/truck pa)			11,700

Source: industry interviews

Table 9 Summary costs of waste collection

	Bag		Bin	
	$/truck pa	$/t	$/truck pa	$/t
Trucks	48,216	12.9	48,216	12.9
Bags/bins	52,800	16.0	31,285	9.5
Labour	76,960	20.5	62,400	16.6
Fuel	11,700	3.5	11,700	3.5
Total	189,676	**53**	153,601	**42**

We have taken a weighted average of the bag and bin costs to derive an overall cost per tonne of waste collected for landfill. Assuming that 10% of households use bins we get a cost of $52 per tonne of waste collected for landfill.

We have captured regional variations by estimating total kilometres travelled by all trucks transporting waste within a district as a function of household density within the region and overall waste being sent to landfill within the region. The formula fitted to existing collection cost data is:

$$TotalKms = a + \frac{b}{\sqrt{D}} + c * T$$

D – Density of households (households/Km^2) within the TA

T – Tonnes of waste sent to landfill in the TA

a, b, c – Parameters estimated (using OLS regression): a = 12.77823, b = 10.86465, c = 0.044572603

Estimated 'TotalKms' for a TA is then divided by the amount of waste being sent to landfill to estimate the kilometres of truck distance per tonne of waste being sent to landfill. Finally, the cost of collection is modelled as a function of kms/tonne, keeping Auckland as a base case.

4.3. Avoided Financial Costs of Landfill

The financial costs of landfill that are appropriate for a cost benefit analysis for public policy purposes are measures of long run marginal costs (LRMC). This assumes that the benefits of savings in waste produced for disposal are those associated with the need for landfills in the long run, ie the need for the next landfill.

We have used landfill gate rates derived from MfE's Landfill Full Cost Accounting Model.[15] The initial parameters used in the model are default or typical values across New Zealand for a Greenfield site; some of the major assumptions are listed below. The indicative gate rate assumes a 20% mark-up for the landfill operator; this is not included in the cost benefit analysis as it is not a resource cost. Rather it is part of the producer surplus that results from a financial transfer from waste producers (businesses, households, local government) to landfill operators. The transfer of money no longer occurs if waste volumes to landfill reduce, but this is not a reduction in costs.

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[15] http://www.mfe.govt.nz/publications/waste/landfill-full-cost-accounting-guide-mar04/index.html

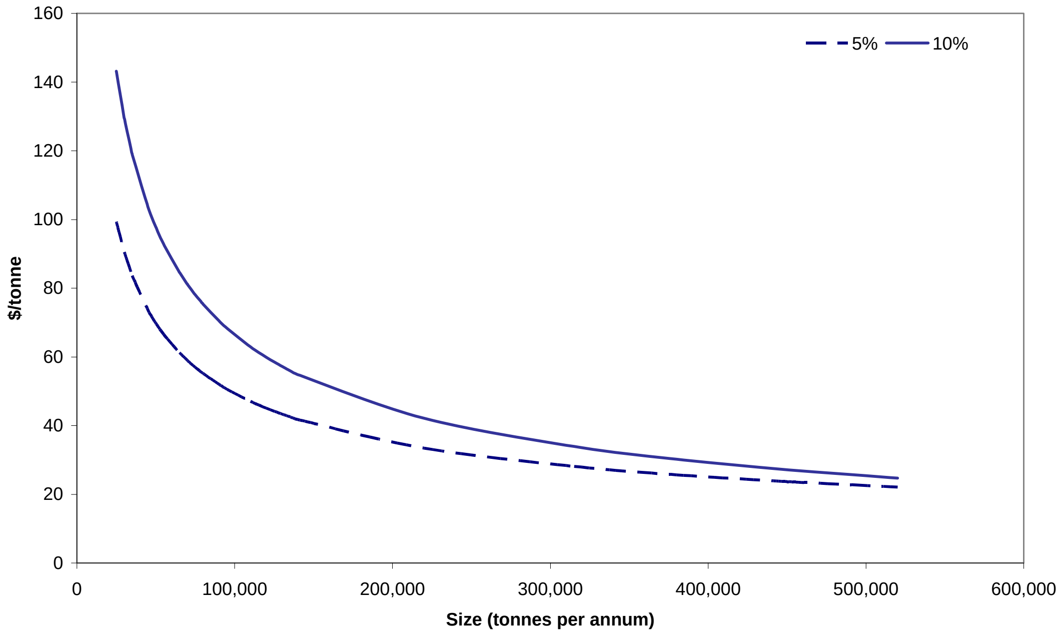
The land acquisition and associated setup costs are assumed to be a function of the capacity of the landfill. We have assumed a linear relation between the setup costs and the annual waste flow to landfill. Setup costs range from $2m to $30m for landfills with annual capacities of 10,000 tonnes to 500,000 tonnes. The setup cost is then annualised and divided by the annual waste flow to get a cost per tonne, which is added to the economic cost of landfill.

Table 10 Assumptions for landfill costs

Input assumptions	
Consented Landfill Operating Life	35 yrs
Actual Operating Life	35 yrs
Aftercare Period	30 yrs
Annual Waste Tonnage at Start of Operation	200000 t/y
Annual Waste Tonnage Growth Rate	0 %/y
Assumed Compacted Waste Density	0.9 t/m^3
Footprint Area	37 Ha
Disturbed Area	51.8 Ha
Land Acquisition & Associated/ Set Up Costs	$13,000,000
Gross Airspace	9862123 m^3

In addition to landfill size, one of the key assumptions for the analysis of costs is the discount rate. The implications of discount rate and size are shown in Figure 3.

Figure 3 Variation in disposal costs with landfill size and discount rate



Source: Ministry for the Environment Full Cost Accounting Model; Covec analysis

The shape of the curves is very similar to that seen in Australian data.[16]

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[16] Australian Government Productivity Commission (2006) Waste Management. Productivity Commission Inquiry Report No. 38. 20 October 2006 p70

In addition to these costs, we assume a transport distance to landfill based on the estimates of landfill locations consistent with Table 7 on page 15 (see Annex 1). An identified location is assumed for each TA to enable the distance to be calculated between it and every other TA. We have estimated the cost of freight using a published freight cost of \$0.0226/m^3 (in 2001)[17] updated to 2007 dollars using a Producers Price Index (PPI) [18] to produce a cost of \$0.0279/m^3. This is then combined with density data to provide a cost per tonne for waste sent to landfill. The same approach is used also for estimating the costs of sending recycled material to market. The material-specific freight costs are shown in Table 11.

Table 11 Freight cost estimates

Material	Density (t/m^3)	Cost (\$/tonne)
Waste	0.15	0.19
Paper	0.47	0.06
Glass	0.347	0.08
Steel	0.226	0.12
Aluminium	0.154	0.18
Plastic	0.29	0.10

Source: Density data from: US EPA

We have used different estimates of freight costs for end-of-life tyres and used oil. Our numbers are based on conversations with industry sources. Our estimates are shown in Table 12.

Table 12 Freight Costs for End-of-life Tyres and Used Oil (\$/tonne.km)

	\$/tonne.km
End-of-life Tyres	0.287
Used Oil	0.206

Source: Industry estimates

4.4. External Costs of Landfill

There are external costs of landfills that are not included in current prices and in our estimates of long run costs of supply above. These are the result of:

- disamenity, which depends on the location of the landfill;
- emissions to the atmosphere, which depends on the material being landfilled;
- leachate levels, which depend on the material being landfilled.

4.4.1. Disamenity effects

Disamenity effects are generally defined as "localised impacts of landfill activity that generate negative reactions from those located in the immediate vicinity of a site;"[19] the impacts include those associated with noise, dust, litter, odour and vermin.

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[17] Transit NZ Heavy Vehicles Limits Project, Report 7 (May 2001), Table 5.1.

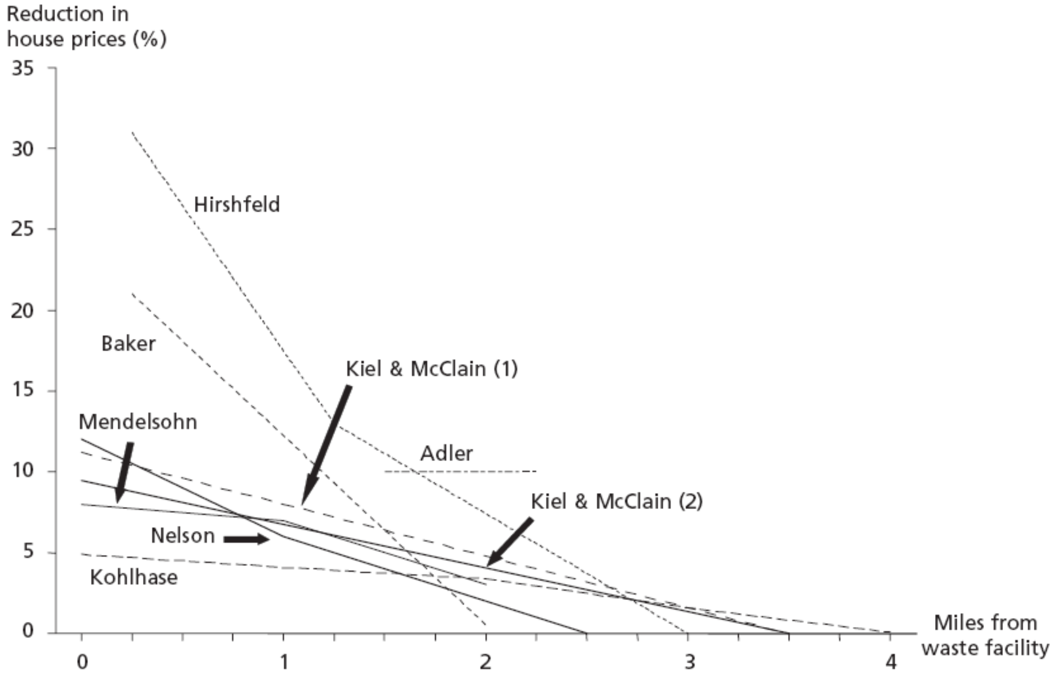
[18] We use input figures of June 2001 = 1220 and December 2006 = 1507 (Statistics New Zealand).

[19] Cambridge Econometrics, EFTEC and WRc (2003) A study to estimate the disamenity costs of landfill in Great Britain. Department for Environment, Food and Rural Affairs. London.

Some of the disamenity effects of waste disposal will apply equally to recycling activity, including those associated with materials recovery facilities; the net effects will depend on whether waste is handled through a transfer station prior to landfilling or if collection trucks go directly to the landfill. Increasingly the norm in New Zealand is for waste to go through a transfer station where it is aggregated, prior to transfer to landfill. Thus we assume that the disamenity effects associated with recycling are equal to the effects of transfer stations and that the disamenity impacts of landfill are an additional cost of landfill disposal and a benefit of recycling.

Measuring the disamenity effects of landfill has been undertaken in overseas studies, particularly US hedonic pricing studies that measure the impacts of landfills on property prices. Figure 4 is taken from a UK report that summarises the results from a number of the US studies. No studies found effects at a distance greater than 4 miles (6.4 km) from a site and the study that found an impact out this far was for a toxic waste facility. As a general rule, house prices increased by 5-8% per mile (3-5% per km) distance from a landfill within this 4 mile radius.[20]

Figure 4 Reduction in house prices as a function of distance from a waste facility



Source: Cambridge Econometrics, EFTEC and WRc (2003) A study to estimate the disamenity costs of landfill in Great Britain. Department for Environment, Food and Rural Affairs. London.

A European study that analysed the disamenity effects associated with landfills in Italy was used to recommend a disamenity cost impact for policy purposes throughout the

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[20] Cambridge Econometrics et al (op cit)

EU.[21] It suggested using a reduction in house prices, for policy purposes, of 2.8% within the odour-affected area. This was based on a population density of 1,648 people/km^2 and 2,000 tonnes per day of waste entering the landfill. Using these and other inputs, the Italian data were converted into a cost per tonne of solid waste of €13.2 per tonne. [22] These input figures are high; the population densities are close to the density of a New Zealand city (the population density of North Shore city was 1,422 people/m^2 in the 2001 census)[23] rather than a rural area likely to be the site of a landfill, and the average input to a municipal solid waste landfill in New Zealand is approximately 156 tonnes per day.[24] These factors would work in opposite direction in converting into an impact per tonne; the lower population density means fewer properties are affected but the fewer tonnes means that the impact is spread over fewer tonnes. This latter point requires clarification, and specifically whether the impacts relate to tonnes delivered or whether they are more fixed in nature, ie whether house values drop simply because there is a landfill or if they drop more if the landfill takes in more waste and therefore produces more dust, litter and odour. This does not appear to have been addressed in the literature.

A UK willingness to pay (contingent valuation) study of a single landfill found 400 houses affected by the landfill and that, for these houses (73 responded to a survey), their willingness to pay for a days reduction in the impacts (dust, litter and odour) was £0.20-31; on the assumption that these effects occur for 50 days of the year, this was used to estimate a benefit of reduction in impacts of £13 per household per year.[25] The landfill was taking in approximately 1,200 tonnes per day of waste and on this basis the impacts per tonne of waste would be only £0.01/tonne (cNZ$0.03/tonne). This study was for an existing landfill that had been established for some time, and it should be noted that marginal costs fall over the life of the landfill; a hypothetical representation of this effect from a UK study is shown in Figure 5.

US contingent valuation studies produced the following higher results:[26]

- US$260/year per household for landfill to be located elsewhere (1991 study);
- US$420-630 per household per year per mile from landfill, where householders were asked to choose a valuation of two houses with identical characteristics except their proximity to a landfill (1986 study).

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[21] European Commission (1995) ExternE Externalities of Energy. In: Cowi Consulting (2000) A study on the Economic Valuation of Environmental Externalities from Landfill Disposal and Incineration of Waste Final Appendix Report. European Commission DG Environment.

[22] Cambridge Econometrics et al (op cit).

[23] StatsNZ.

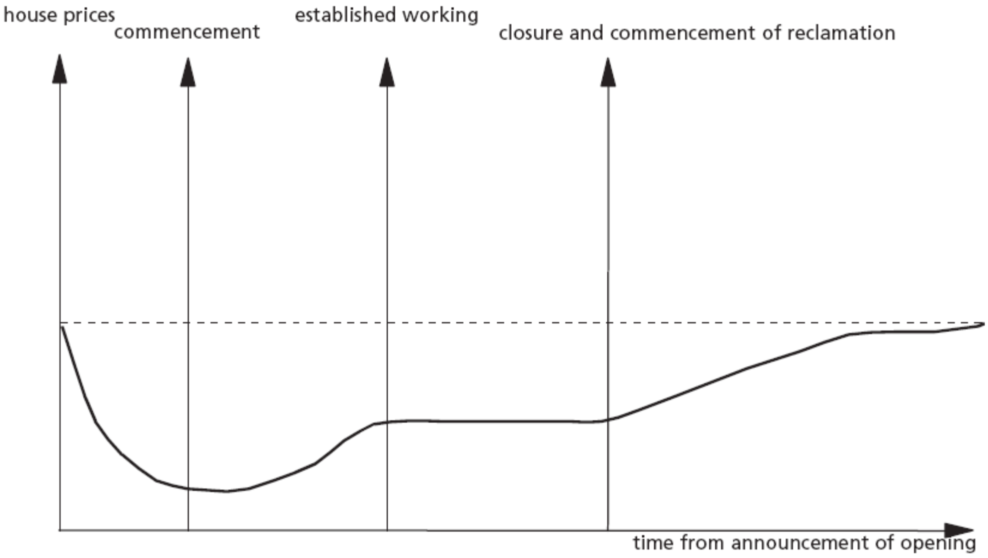
[24] 3.25 million tonnes of waste going to 57 landfills (Ministry for the Environment data) .

[25] Garrod G and Willis K (1998) Estimating lost amenity due to landfill waste disposal. Resources, Conservation and Recycling, 22(1-2): 83-95 In: Cambridge Econometrics et al (op cit) and Cowi Consulting (2000) A study on the Economic Valuation of Environmental Externalities from Landfill Disposal and Incineration of Waste Final Appendix Report. European Commission DG Environment.

[26] Cambridge Econometrics et al (op cit).

The recent UK study, undertaken for policy purposes, [27] suggested that the hedonic (house price) studies were the most appropriate and that the value of housing stock close to landfills was being significantly lowered. It found that this was statistically significant within a 0.5 mile radius. It estimated total disamenity impacts in the UK associated with landfills of £2.5 billion and an impact per tonne of £1.86 in 2003 prices or a range of £1.52-2.18/tonne. This was based on 1995 estimates of a £5,500 loss in value for houses within 0.25 miles of the landfill and £1,600 for houses in the 0.25-0.5 mile zone; these were updated using a consumer price index.

Figure 5 Hypothetical landfill disamenity impacts



Source: Cambridge Econometrics, EFTEC and WRc (2003) A study to estimate the disamenity costs of landfill in Great Britain. Department for Environment, Food and Rural Affairs. London.

The Australian Productivity Commission cited the work for the European Commission and others, in suggesting that, if a landfill is located more than five kilometres from residential areas, the costs of lost amenity are likely to be less than $0.01 per tonne of waste, but that if located in a built-up area and poorly managed, the loss of amenity can impose external costs up to $3.70 per tonne. The Commission assumed that the typical amenity cost of a properly-located, engineered and managed landfill is less than $1.00 per tonne of waste.

For New Zealand a number of telephone conversations with rural estate agents revealed views that varied between "landfills are never located anywhere near houses so they won't have any effects on property prices" and that the impact will be significant.

For this study, it is assumed that most of the amenity effects are limited through location so that the number of houses affected by a landfill will be quite small and significantly lower than the numbers used in the European studies. The UK numbers generated for policy reasons above are equivalent to approximately NZ$4-6 per tonne, but again the assumption is that the property density and house prices will be higher.

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[27] Cambridge Econometrics et al (op cit)

For analysis we take the simple numbers suggested by the Australian Productivity Commission, ie a cost of no more than A$1 per tonne, as a low-end estimate of disamenity costs of landfills; we assume a simple NZ$1 per tonne. For a high-end estimate, we use $8.94 per tonne, based upon the UK hedonic study value of £1.86/tonne.[28]

There is some argument that the amenity effects will differ between waste streams, ie some waste smells and others produce litter. A UK study found a different willingness to pay related to these separate effects, however they were similar in size.[29] We assume that the effects are not additive but similar in size and therefore use the same disamenity effect for all waste streams.

4.4.2. Emissions to air

Carbon dioxide (CO_2) and methane are the most significant emission to air from landfills.[30] However, methane is the only emission that is counted because the CO_2 produced is associated with carbon that was recently absorbed (organic material) or for which emissions have already been counted.[31] Methane emissions are the most significant. Baseline emissions are estimated using the same input assumptions and approaches as used in the national greenhouse gas inventory (Table 13 and Table 14), although a slightly different methane density is adopted using MED assumptions.

Table 13 General Input assumptions for estimating methane emissions

Inputs	Values
Methane Correction Factor (MCF)	0.984
Fraction of Degradable Organic Carbon that degrades	0.5
Fraction of C released as methane	0.5
Conversion C to CH_4	1.3333
Methane density (kg/m^3) [1]	0.6780

Source: MfE (2006) New Zealand's Greenhouse Gas Inventory 1990 – 2004 The National Inventory Report and Common Reporting Format; [1] MED (2007) Energy Data File September 2006

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[28] The UK estimate has been adjusted to account for exchange rates and changes in house prices over time. The price deflator used in the study was 1.12 (to take back to 1995 values when the study was undertaken) and to adjust for differences in property values a UK average house price of £65,000 in 1995 (www.statistics.gov.uk) and a current New Zealand average house price of $350,000 were used (Quotable Value Ltd).

[29] Garrod G and Willis K (1998) Estimating lost amenity due to landfill waste disposal. Resources, Conservation and Recycling, 22(1-2): 83-95 In: Cambridge Econometrics et al (op cit) and Cowi Consulting (2000) A study on the Economic Valuation of Environmental Externalities from Landfill Disposal.

[30] European Commission DG Environment (2000) A Study on the Economic Valuation of Environmental Externalities from Landfill Disposal and Incineration of Waste.

[31] Emissions from timber and timber products, including paper, are counted when trees are first felled.

Table 14 Methane emission generation potential for specific waste streams

	Quantity	Waste composition	Degradable Organic Carbon	Methane generation potential	
	(tonnes)	(%)		(tCH_4/t waste)	(m^3/Gg)
Paper	386,697	12.7%	40%	0.1312	193.5
Organic	752,080	24.7%	17%	0.0558	82.2
Timber	380,607	12.5%	30%	0.0984	145.1
Total	3,044,857		13%	0.0427	63.0

Source: MfE (2006) New Zealand's Greenhouse Gas Inventory 1990 – 2004 The National Inventory Report and Common Reporting Format; Covec calculations

These methane generation potential estimates are combined with assumptions that 72% of landfills have gas capture systems and an average efficiency of capture of 44%. The estimated net emissions include an oxidation factor correction based on internationally agreed (IPCC) methodologies.[32] A net emissions rate is calculated in terms of CO_2 equivalents based on a Global Warming Potential (GWP) of 21 for methane (CH_4).

Table 15 Net methane emission rates for specific waste streams

	Waste	Methane generation potential	Gross annual methane generation	Reco-vered CH_4	Net methane generation	1-oxidation factor	Net CH4 emissions	Net emissions rate
	(kt)	$ktCH_4$/ kt waste	kt	kt CH_4	kt CH_4		kt CH_4	t $CO_{2\text{-}e}$ /t waste
Paper	387	0.1312	50.7	16.13	34.6	0.9	31.1	1.69
Organic	752	0.0558	41.9	13.34	28.6	0.9	25.7	0.72
Timber	381	0.0984	37.5	11.91	25.5	0.9	23.0	1.27
Total	3,034	0.0427	129.7	41.23	88.4	0.9	79.6	0.55

This is used to provide estimates of the value of diverting waste from different waste streams using values of CO_2 emissions of $15 and $25/tonne (Table 16).

Table 16 Value of waste diversion

Waste stream	Net emissions rate t $CO_{2\text{-}e}$ /t waste	$/t @ $15/t	$/t @ $25/t
Paper	1.69	25.4	42.3
Organic	0.72	10.8	18.0
Timber	1.27	19.0	31.7
Total	0.55	8.3	13.8

4.4.3. Leachate

Leachate is generated when soluble components of the waste stream are transported out of mixed waste through the action of water. Leachate can enter groundwater potentially resulting in environmental and/or health problems, particularly if it enters the food chain. Despite this process being well understood, there appears to be a shortage of

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[32] MfE (2006) New Zealand's Greenhouse Gas Inventory 1990 – 2004 The National Inventory Report and Common Reporting Format.

scientific research and evidence regarding the actual effects of leachate, particularly how it is transmitted once it leaves a landfill.[33]

In addition, there is no certainty that a particular landfill will generate leachate; it could remain confined in a landfill indefinitely, or until it is appropriately treated and discharged to sewers. In other cases, leachate could leak through landfill liner but be confined by impermeable bedrock. The risks of damage from leachate depend on the location of the landfill, its construction and how leachate is managed. The New South Wales Environmental Protection Agency considered that landfills that comply with environmental management guidelines are unlikely to spill leachate into the surrounding environment and so would not generate any adverse external effects.[34] The Australian Department of the Environment and Heritage stated:

> … the majority of landfills currently servicing major population centres now meet stringent planning and regulatory requirements in relation to location, design, construction and operation. Consequently, such landfills generally do not present significant risks in terms of generating external environmental costs through air and water pollution, noise, dust and the generation and spread of disease. (sub. 103, p. 16)

Various studies have attempted to estimate the cost of leachate. The BDA Group and EconSearch[35] estimated that the external cost of leachate from Australian landfills is less than A$0.01 per tonne of waste. Miranda and Hale estimated that the external cost of leachate from landfills in the United States is between zero and $1.40 (US$0.98) per tonne of municipal waste.[36]

Nolan-ITU estimated the benefits of reduced water emissions that arise from diverting mixed waste from a 'best practice' landfill in Australia.[37] The Australian Productivity Commission's interpretation of Nolan-ITU is that its estimate of the external cost of leachate from a 'best practice' landfill is between $48 - $100 (A$43 - $89) per tonne of mixed waste. The Australian Productivity Commission considered that Nolan-ITU had assumed that all the leachate generated in a landfill would escape and cause environmental damage, and that the cost of the damage is not influenced by the geological or other characteristics of the surrounding area. These assumptions do not appear to be consistent with the siting and design of a 'best practice' landfill. The Commission also considered that the Nolan-ITU estimate did not fully take into account the capture of contaminants by leachate treatment, or the capacity of clay liners to adsorb some of the pollutants in leachate.

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[33] European Commission, 2000.

[34] NSW EPA 1996, Proposed Waste Minimisation and Management Regulation, Regulatory Impact Statement , Sydney.

[35] The BDA Group and EconSearch, 2004, Final Report to Zero Waste SA: Analysis ofLevies and Financial Instruments in Relation to Waste Management, Zero Waste SA, Adelaide.

[36] Miranda and Hale, 1997 'Waste not, want not: the private and social costs of waste-to-energy production', Energy Policy, vol. 25, no. 6, pp. 587–600.

[37] Nolan-ITU, 2004, Global Renewables: National Benefits of Implementation of UR-3R Process: A Triple Bottom Line Assessment, Sydney.

The widespread use of best practice landfills limits the likely effects of any leachate that is generated. This suggests that an externality of around $1 per tonne is appropriate for such landfills. This is consistent with most of the international studies. However, because a proportion of landfills are not likely to adhere to best practice standards, a high-end estimate of external leachate costs of $37 is also included in our analysis. This is based upon the mid-range of the Nolan-ITU estimate, $74, scaled down 50%. The Nolan-ITU estimate is scaled down to account for the fact that an increasing proportion of landfills will meet best-practice standards. Specifically, of the 43 landfills predicted to be operating in 2010:[38]

- 43% will be sited over low-permeability material
- 67% will have an engineered liner
- 88% will have leachate collection systems
- all will have effective stormwater diversion in place,
- 67% will treat stormwater prior to discharge
- 93% will cover waste on a daily basis.

Leachate benefits are applied to savings in landfilling of organic waste and used oil.

4.5. Direct Consumer Benefits

The direct consumer benefits of recycling are discussed in Section 2.1.1. As part of this study a survey of households was undertaken by AC Nielsen. The survey was conducted using the Nielsen Online Omnibus that covers 1,000 interviews with people aged 18 and over. A national sample is selected and results are weighted (by age, gender, region, internet access and frequency) to reflect the NZ population. Interviews were completed online between the 23rd and 30th of January 2007. The set of questions asked is included in Annex 2.

To reduce any potential bias in the pricing questions, half the respondents were presented with a list showing low to high prices, whilst the other half saw the list reversed showing high to low prices.

The detailed analysis of the survey is presented in Annex 3. It assesses the willingness to pay to recycle in terms of time and money, for a number of different waste streams and compares this with the current time or money spent on recycling; the difference represents a consumer surplus used as an estimate of direct consumer benefit.

4.5.1. General Household Recycling

The data for general household recycling are assumed to apply to glass, plastics and paper; separate questions were asked for household organic waste. The survey found the difference between the current time households spent recycling and the willingness to pay for recycling is 10.1 minutes per week per household. Time saved was valued at

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[38] Ministry for the Environment (2003) 2002 Landfill Review and Audit.

$5.20 per hour using assumptions derived from transport studies;[39] this results in a value of $0.88/household/week.

In estimating a willingness to pay per tonne of waste, one of the key issues is the appropriate denominator. There are a number of possibilities (Table 17). The mid-value ($183/tonne) assumes that the willingness to pay or spend additional time relates to the existing volume of collected material. The high value assumes that an additional amount (2.3kg) was collected but would take no additional time. The low value assumes that the willingness to pay/ spend time relates to the total inorganic recyclable volume but that collecting the additional quantity (2.3kg) takes proportionally the same amount of time as collecting the existing volume.

Table 17 Value of household recycling

Categories of waste	Kg/household/week
a) Inorganic waste currently recycled by households with weekly collections	4.8
b) Inorganic waste not currently recycled but could be	2.3
Denominator	**$/tonne**
Low (a + b = 7.1)	44
Medium (a)	183
High (b)	383

The resulting range of values is $44-383/tonne as a direct value to consumers of recycling, with a medium value of $183/tonne based on 4.8kg. The survey also found that people were willing to pay $1.68/week to recycle plastics, paper and glass (PP&G), which implied a surplus of $350/tonne (based on 4.8 kg per week), [40] thus the values used above are likely to be conservative.

4.5.2. Organic Waste

Survey respondents said they were willing to pay $1.50/wk to recycle organic waste. However, we do not have estimates of how much time it would take to recycle, ie for households to separate this material for collection and recycling.

The total amount they are willing to pay is higher per week than it is for the other recyclables stream ($0.88/wk), but it is likely that the costs or time taken by households would be higher also. We have assumed the same direct consumer benefits as for the other household stream.

4.5.3. Tyres and Oil

For tyres and oil we assumed that households currently do not pay or spend time recycling these items, and the stated willingness to pay was a pure surplus. Households were willing to pay $2.22 for a tyre and $2.10 for each oil change. We assume that one tyre weighs 8kg, 5 litres of oil are used in each change, and 1 litre of oil weighs 0.9kg.[41] We calculated this surplus as $278/tonne for tyres and $467/tonne for oil. There is some

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[39] See Annex 2. A value for car passenger time in non-work travel purposes was used

[40] If we use this stated willingness to pay as a substitute for time, then the suggested value of time in recycling is $9.98/hour.

[41] Based on light fuel oil density – MED (2006) Energy Data File September 2006

question over the validity of including these results for tyres and oil because of the lack of an obvious market failure, ie garages could recycle and extract these amounts from consumers currently. However, market failures are likely to exist in the form of information failures (garages do not know of consumers' willingness to pay) and coordination failures (a single garage is unlikely to be able to find a ready market, particularly for the identified markets for tyres.

The range of assumption used in analysis is given in Table 18.

Table 18 Direct consumer benefits of recycling

Waste Stream	Low value ($/tonne)	Best guess value ($/tonne)	High value ($/tonne)
Paper, plastic, glass, metals	44	183	383
Organics	44	183	383
Tyres	0	278	278
Oil	0	467	467

4.6. Total Externalities

The total externalities are shown in Table 19. They are dominated by the estimated direct consumer benefits.

Table 19 Total external benefits (avoided costs) of recycling

Externality	Low Value ($/tonne)	High Value ($/tonne)
Avoided disamenity impacts (all waste)	1	8.94
Avoided greenhouse gases		
Paper	25	42
Organic	11	18
Timber	19	32
Avoided leachate (organics, used oil)	1	37
Direct consumer benefits		
Paper, plastic, glass, metals	44	383
Organics	44	383
Tyres	0	278
Oil	0	467

5. Markets and Value of Materials

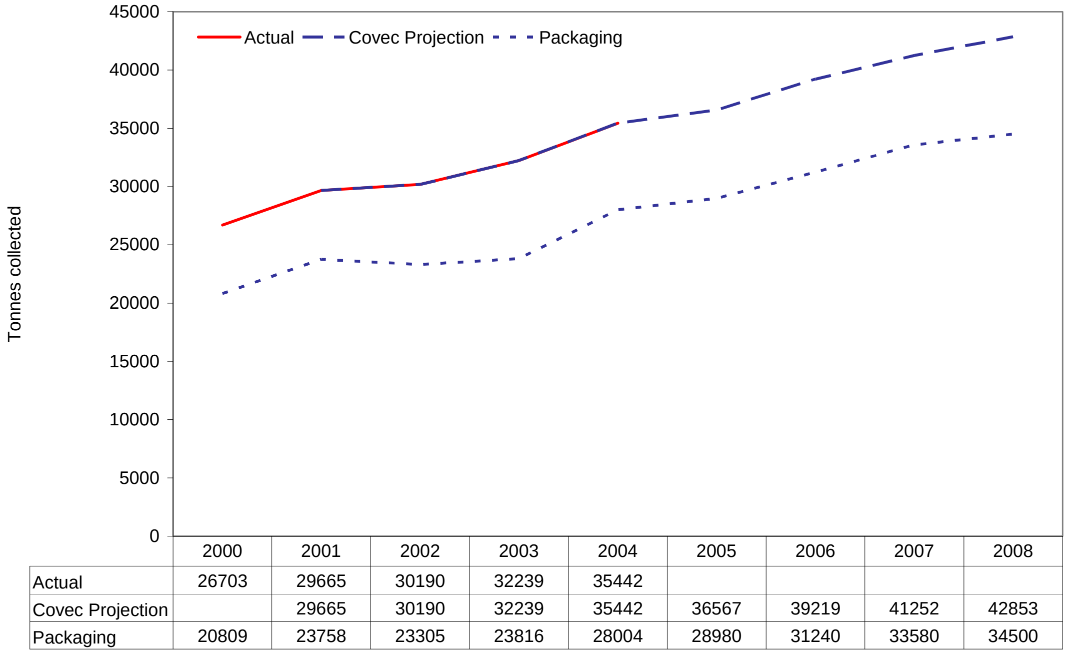
The value of the different materials collected represents the final component of value of recycling. In this section we outline the markets in New Zealand for the different products and provide estimates of the value.

5.1. Plastics

5.1.1. Quantities

An estimated 35,442 tonnes of plastics were recovered in New Zealand in 2004 of which 79% (28,004 tonnes) was packaging.[42] Projections have been made by Plastics New Zealand of future recovery rates for packaging plastics. Total quantities recovered were regressed against time, the previous year's recovery rate and actual or projected packaging recovery to project future plastic recovery rates. These suggest that approximately 41,000 tonnes will be recovered in 2007 (Figure 6).

Figure 6 Quantities of plastics recovered for recycling



	2000	2001	2002	2003	2004	2005	2006	2007	2008
Actual	26703	29665	30190	32239	35442				
Covec Projection		29665	30190	32239	35442	36567	39219	41252	42853
Packaging	20809	23758	23305	23816	28004	28980	31240	33580	34500

The material collected is divided into different plastic types as shown in Table 20 and into sources: industrial (64%)[43] and post-consumer domestic (36%).[44]

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[42] Plastics New Zealand (2005) Sustainable End-of-Life Options for Plastics in New Zealand.

[43] Of which 13% is pre-consumer industrial and 51% is post-consumer industrial.

[44] Plastics New Zealand (2005) Sustainable End-of-Life Options for Plastics in New Zealand.

Table 20 Total quantities of plastics recovered by material type

	PET	HDPE	PVC	LDPE	PP	PS	EPS	Other
2000	17.9%	21.5%	8.2%	24.6%	2.1%	3.7%	0.0%	22.1%
2001	18.4%	24.5%	9.6%	33.0%	1.8%	0.6%	0.0%	12.2%
2002	19.6%	24.7%	8.8%	36.8%	4.2%	1.1%	0.0%	4.9%
2003	20.7%	23.4%	7.6%	33.1%	3.9%	1.1%	0.3%	10.0%
2004	22.6%	25.2%	6.8%	35.1%	4.0%	1.2%	0.6%	4.5%
Average	20.0%	23.9%	8.1%	32.8%	3.3%	1.5%	0.2%	10.2%

Source: Plastics New Zealand (2005) Sustainable End-of-Life Options for Plastics in New Zealand

5.1.2. Markets

Most of the pre-consumer industrial waste is scrap and products that were out of design recycled in-house.

Plastics are recycled in a number of plants in Auckland and one in Otaki. Values of materials have been obtained from recycling industry representatives and from Plastics New Zealand. The results are shown in Table 21.

Table 21 Values of plastics in end-use markets

Material	Material	Value $/t (2005)	Estimated value $/t (2007)	Assumptions $/t
1 PET	non-coloured	500-550	500-700	600
	coloured	350		
	flaked	550-600		
2 HDPE	milk bottles	400-450	1,000	700
	pelletised	600		
	janitorial-grade	250	450	
3 PVC			300	300
4 LDPE				300
Other				300

5.2. Paper

The most significant markets for paper in New Zealand are Carter Holt Harvey's mills at Penrose (Auckland), Kinleith and Whakatane. In addition there are smaller local markets for the production of moulded fibre (egg cartons and apple trays) and for hydro-seeding.[45] There is no real market for office paper in New Zealand, separate from that for lower value grades. Values of materials are based on long run US (New York)[46] estimates of approximately $50/tonne for mixed paper and $140/tonne for white office paper (Figure 7); this is translated to NZ values using an exchange rate of US$0.6:NZ$1 and converted to metric tonnes. We have used a simple assumption of $90/tonne for all markets in New Zealand.

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[45] Plant seeds are combined with fertiliser and fibre made from recycled paper to make a mixture that can be sprayed onto the ground or other landscape feature, ensuring that the seed mixture sticks to the soil surface until germination

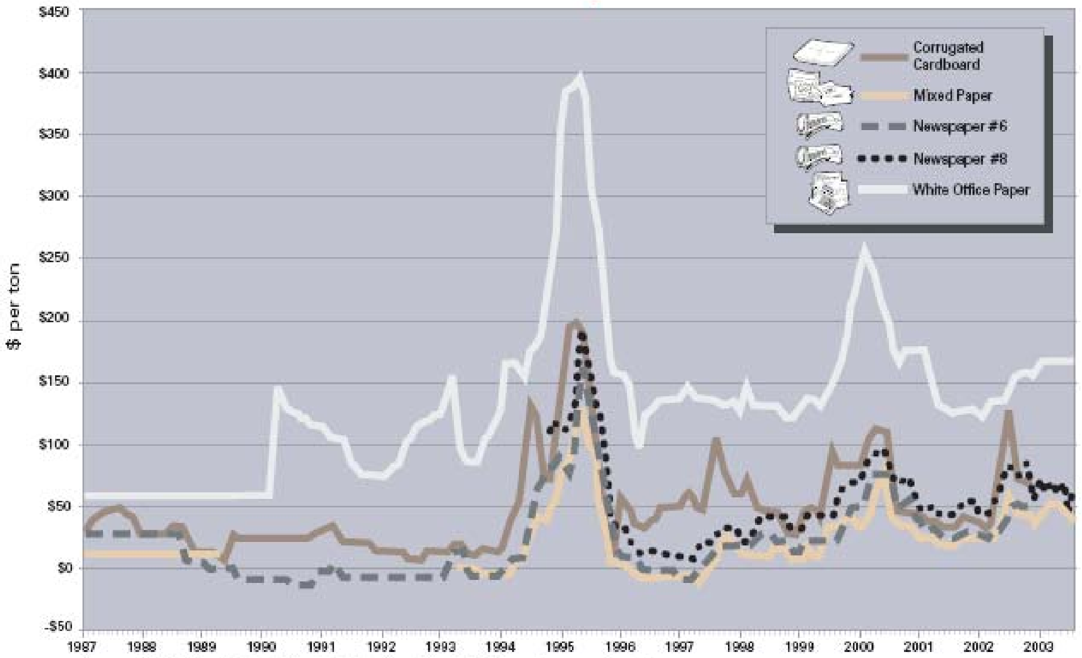
[46] Using New York figures was recommended by Louisa Palmer (Ministry for the Environment) as representing a good approximation of New Zealand prices

Table 22 Size and value of recycled paper markets

Market	Use	Size (tpa)	Value ($/t) Other paper	Value ($/t) Office paper
Auckland - Penrose	Paperboard manufacture	90,000[1]	$90	
Auckland - other	Moulded fibre	2,000	$90	
Kinleith	Paper manufacture	120,000[2]	$90	
Whakatane	Paper manufacture	2,000[3]	$90	
Other	Hydro-seeding	~500	$90	
Export		unlimited	$90	NZ$257

[1] http://www.chhwhakatane.com/WSMApage/0,1585,14107-1,00.html; [2] http://www.fullcircle.org.nz/ ; [3] Covec estimate

Figure 7 Recycled paper prices - New York region



Source: Official Board Markets. See "Notes to Illustrations" for information on pricing data.

Source: Bureau of Waste Prevention, reuse and Recycling (2004) Processing and Marketing Recyclables in New York City. Rethinking Economic, Historical, and Comparative Assumptions. Rethinking Economic, Historical and Comparative Assumptions. New York City Department of Sanitation ww.nyc.gov/html/nycwasteless/html/recycling/waste_reports.shtml#mkts

5.3. Glass

Glass is manufactured in New Zealand in a single plant in Penrose, Auckland operated by O-I New Zealand. Approximately 95,000 tonnes of glass is recovered currently of which about 70-80,000 tonnes is used by O-I.

The value of materials in glass manufacture is based on the costs of manufacturing glass from alternative materials. Recently O-I reduced the price paid for cullet from $92/tonne for all types of glass to $75/tonne for coloured glass and $10/tonne for clear glass.[47] An analysis of the costs of manufacture of glass from alternative raw materials versus cullet was used to confirm that the revised price paid for coloured glass was close to the costs of manufacture from raw materials.[48] For clear glass, the market price is set so that supply is constrained and the price paid is well below the value of the material in glass manufacture.

For cost benefit purposes, the market value for clear glass is assumed to be the value in recycling at O-I for all its consumption. The difference between the current price paid and this value is regarded as a surplus to O-I.

O-I New Zealand intends to invest in a third glass furnace which could increase its ability to recycle green glass by approximately 50% above the existing capacity (to more than 100,000 tonnes per annum). This furnace was scheduled to become operational in 2007 but has now been deferred for a minimum of twelve months due to capital cut-back across the O-I Group worldwide.

In analysis we assume there is a market for coloured glass in bottle manufacture in Auckland equal to 70,000 tonnes per annum and for clear glass equal to 10,000 tonnes per annum, and both are valued at $75/tonne. All glass collected above these amounts is valued at zero.

5.4. Metals

Aluminium and steel are collected and recycled. The value of the collected materials is determined by the international prices of the raw materials as stated on the London Metal Exchange. We use the following prices for these materials based on long run averages rather than current relatively high prices:

- $1700/tonne for aluminium;
- $120/tonne for steel

5.5. Organics

Organic waste sent to landfill consists largely of food scraps and domestic garden material. Of household refuse, 40 – 50% is organic material, resulting in approximately 400,000 – 430,000 tonnes being landfilled per year. Commercial organic waste is generated from two main sources: restaurants and the food industry, and agriculture. The majority of the greenwaste created by the agricultural sector is already recovered whereas most of the kitchen waste generated in the food sector is not, although there are several small scale operations that recover foodwaste from commercial kitchens. The

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[47] These prices are paid at the gate of the Visy-run beneficiation plant rather than at the OI gate. There is further processing of this material, prior to use by OI. Beneficiation costs are ignored in the analysis because we use pre-beneficiation prices paid.

[48] Covec (2005) Independent analysis of glass packaging recovery and analysis. Report to the Packaging Council of New Zealand and the Packaging Accord 2004 Governing Board.

total amount of domestic and commercial organic waste sent to landfills is estimated at 760,000 tonnes.[49]

Options for recovering a greater proportion of organic waste include having separated kerbside collection. Such collections can have a number of different design features including using bags or mobile bins for collection, frequency of collection and which specific types of organic waste are collected and how they are treated. For instance, different climactic conditions may mean different TAs may need to treat the collected material differently. The prevalence of multi-tenanted dwellings in certain locations may also influence the types of collection methods.

The price of compost in the small-scale domestic market is around $30 - $50 per tonne, whereas in the larger-scale agricultural market the price may be as low as $10 - $15 per tonne. These prices are sufficient to ensure the sale of the current quantity of compost produced. However, industry estimates suggest that if the price paid in the agricultural sector were reduced to $5 per tonne, the resulting demand would be sufficient to utilise the compost that could be produced if all of the country's organic waste was collected. The price the agricultural market is willing to pay is determined partly by the additional costs that would be incurred in the process of spreading compost over the ground. Spreading compost can be costly, requiring specialised machinery (ie spreader trucks or spreaders pulled behind tractors) and labour. These costs are estimated to be in the vicinity of $15 - $20 per tonne.[50] Also relevant to the returns from compost is that one tonne of greenwaste converts to just over half a tonne of compost and the ratio of greenwaste to foodwaste used in the production of compost is 3:1. Existing commercial composting operations also charge dumping fees for greenwaste. These fees will be some proportion less than the local landfill charges.

5.6. Construction and Demolition Waste

Approximately 850,000 tonnes of construction and demolition (C & D) waste is disposed of in landfills. A large amount of C & D waste is also disposed of in cleanfills. Cleanfills are waste disposal sites that accept only inert wastes, such as concrete, bricks and natural materials. Because these materials do not have an adverse effect on the surrounding environment there is no need to control for leachate or hazardous substances. The total amount of material sent to cleanfill is estimated at 2.7 million – 3.7 million tonnes, with a large proportion likely to be natural materials, ie soil, clay, stone and rock.[51] MfE estimates that, in addition to waste disposed of in landfills and cleanfills, around 1 million tonnes of C & D material is recovered.[52]

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[49] "Waste Composition and Construction Waste Data", Waste Not Consulting, February 2006. This amount does not include sewage sludge.

[50] "The Costs and Benefits of Applying Biosolids Compost to Vegetable, Maize/Sweetcorn Production Systems in New Zealand", E. Cameron, N. How, S. Saggar, C.W. Ross, Landcare Research Ltd, 2004.

[51] "Waste Composition and Construction Waste Data", Waste Not Consulting, February 2006.

[52] "New Zealand Waste Strategy", MfE, 2006.

Wood (38%), and concrete and rubble (25%) constitute the main categories of C & D waste sent to landfill.[53] Other items include plasterboard, metal, expanded polystyrene, window glass and various salvageable items, such as windows, doors, fittings, etc. Given the relatively small proportion of these materials, this analysis focuses on wood, concrete and rubble.

Timber and wood fibre sent to landfill consists of 450,000 tonnes with an unknown quantity sent to cleanfills. Wood can be used for a variety of different purposes, ranging from low-quality, temporary work like survey pegs and boxing for concreting to high-quality, permanent uses like floor boards, beams and other architectural features if the recovered material is native hardwood. Along with the well established market for recovered native timber and second-hand sales of pine timber for construction, renovation, craft work, etc, untreated timber off-cuts can be chipped into mulch and used in landscaping, used as firewood in private residences or converted into heat energy through larger scale combustion.

Wood from C & D waste competes with forestry and manufacturing wood waste as an input for industrial furnaces and boilers, particularly in pulp and paper mills. The value of wood and wood products used as fuel is approximately $108 per tonne.[54]

Concrete and rubble can be crushed and used as aggregate for roading, pavements and drainage and can be used as a base material to rehabilitate quarries and construction industry uses, such as filling foundations and underground pipework. Based upon charges for sorting mixed C & D waste that is delivered to recycling centres, the cost of sorting concrete is around $7 per tonne. The cost of preparing the concrete and rubble for crushing, which typically requires pulverisors and excavators to break the material into smaller pieces suitable for crushing, is around $4 per tonne. The cost of crushing concrete is around $8 per tonne.

However, while using crushed concrete as aggregate is a viable alternative to natural aggregate in Auckland and Waikato regions, this is not the case in all areas. For instance, because of the plentiful supply of river gravel in the Canterbury region, extraction is often encouraged to reduce the risk of flooding. This gravel provides a lower-cost substitute for recovered concrete and rubble for aggregate. Thus, diverting concrete and rubble from landfill and cleanfill in areas such as Canterbury could incur additional costs as either the concrete or river gravel would need to be transported to other areas or alternative flood protection measures would need to be undertaken. Consequently, the price for aggregate is relatively localised. Site specific factors, including the charge for accepting C & D waste which depends upon local landfill charges, also influences the viability of C & D recovery.

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[53] http://www.mfe.govt.nz/issues/waste/construction-demo/index.html.

[54] This is based on an estimate of the value of wood waste recovered from forests of approximately $6 per GJ and an energy content of recovered wood of approximately 18 MJ per kg.

5.7. Tyres

Approximately four million tyres require disposal annually. Roughly 75% of these are landfilled, 10 – 15% are re-used in some form and the rest are illegally dumped.[55]

Potential alternative uses for tyres include use as an energy source, material recovery (ie rubber, which can be used for sports arena and road surfaces, and steel), silage covers on farms or for civil engineering purposes, such as in retaining walls, anti-erosion measures, etc.

Of these re-use options, the most appropriate and least-cost method of dealing with used-tyres is likely to be as a source of energy, specifically as fuel for cement kilns. This is because it is unlikely that there would be sufficient demand for other uses, such as rubber recovery for flooring and sports arena surfacing, to use all four million that are created each year. Additionally, the temperature at which tyres would be burnt in kilns would minimise environmentally harmful emissions, the main by–products created from combustion being carbon dioxide and water. Whole tyres can be used for incineration, avoiding the costs of quartering or shredding, typically required before tyres will be accepted by landfills.

In addition to the value of tyres as a source of energy and the avoided landfill costs, (estimated cost of collecting, shredding, transporting and landfilling tyres is $1.50 - $2 per tyre)[56] recycling tyres would reduce the costs associated with illegal dumping and tyre fires. Disposing of illegally dumped tyres is estimated to cost around $1 per tyre. In some instances, up to 60,000 - 80,000 tyres have been illegally dumped on both private and public property. A recent tyre fire in the Waikato took 16 hours to put out at a cost of $90,000, excluding the environmental costs associated with the emissions.

There are additional costs of switching to using tyres instead of coal for fuel: the one-off, capital costs relating to adjusting the kilns to accept tyres rather than coal, and any resource consent costs that would be incurred to allow alternative fuels to be used. These costs are not expected to be significant in relation to the ongoing fuel costs.

An alternative use for tyres is as an input into the roading surface bitumen. This practice is common overseas and provides a higher quality of bitumen than current petroleum based inputs. This process requires end-of-life tyres to be ground into granules, known as rubber crumb. This rubber crumb can be used to replace some proportion of the petroleum-based products used in the production of bitumen. Because the size of the granules required for this process are much smaller than for other uses, such as sports area floors, the costs of grinding are likely to be higher.

Using rubber crumb is more expensive than existing inputs and, although bitumen made with rubber crumb may have a longer life, it is not certain that this would be financially advantageous over existing production techniques.

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[55] "Product Stewardship Case Study for End-of-life Tyres", URS, May 2006.

[56] "Management of End-of-life Tyres", Firecone, January 2004.

5.8. Used Oil

Approximately 65 million litres of oil are purchased each year. Roughly 40% of this is consumed during use, leaving around 33 – 40 million litres of used oil that requires disposal. Of this used oil, 15 million litres is collected and delivered to Holcim Cement for use as fuel. A further 9 million is used in industrial burners, processed into fuel oil or used for public road oiling.

This leaves 9 – 16 million litres of used oil which is unaccounted for. Uses for this include private road oiling and various agricultural and other private uses with some proportion being landfilled (for example, landfilled oil filters could contain up to 500ml of oil) or dumped illegally. Because much of this oil may be used "productively" it may not be able to be collected even if more collection facilities or services were available. For example, workshops may use used-oil for their own burners or heaters to avoid expenditure on electricity, etc.

All additional used oil collected could be used at the Holcim Cement kiln, and potentially at other industrial burners, such as pulp and paper mills or the Golden Bay Cement kiln. However, to be used as a source of energy, these furnaces are likely to need a relatively constant supply of used oil. This is because of the technical requirements of industrial furnaces, which need to be set up to receive a specific mixture of different fuels. The value of this oil is around $0.17 per litre.[57]

Potential users of any additional used oil collected include those industrial activities that operate large scale furnaces, such as the two cement kilns described above and the various pulp and paper mills, for instance Kinleith, Kawarau, Whakatane, PanPac (Napier) and Winstones (Ohakune).

5.9. Summary of Values

The values used in analysis are shown in Table 13. Costs of getting materials to market are estimated in the next section.

Figure 8: Value of recovered materials

Material	$ per tonne
Plastic	300 - 700[1]
Paper (domestic & export)	90
Paper (export office paper)	257
Glass	75[2]
Aluminium	1700
Steel	120
Compost (agricultural use)	5
Compost (domestic)	30 – 50
Chipped wood	108
Crushed concrete	12.70
Tyres	104 – 136
Used oil	(0.17 per litre) 189

[1] see Table 21; [2] clear glass is assumed to have a value of $75 despite its $10 market price.

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[57] This is based upon a energy content of 36 – 37 MJ per litre.

6. Costs of Recycling

6.1. Cost components

The benefits of recycling that were outlined in the previous sections need to be offset by the costs. In this section the net costs of recycling are estimated

6.2. Kerbside collection costs

We develop generic costs for the collection of household materials for recycling. The costs are built up from the component parts as shown in Table 23. These assume collection of all materials except paper. These costs are used to estimate costs for individual materials, including paper, by adjusting for densities of materials.

Table 23 Kerbside recycling cost assumptions

	Crate systems	Co-mingled
Trucks		
Truck ($/truck)	120,000	220,000
Lifetime	7	7
Tonnes/truck pa	750	1,200
Fixed costs/truck pa	2,000	2,000
households/truck	4286	5333
Crates/bins		
Crate/bin ($/item)	10	38
Life	5	5
Number per household	1	1
kg/household/week	3.5	4.5
$/t	15	45
Labour		
Driver ($/hour)	16	16
Runner ($/hour)	14	14
Runners/truck	2	0
Hours/day	8	8
Days per week	5	5
Labour/truck pa	76,960	33,280
Fuel		
l/100km	45	45
Distance per truck per day	100	150
Fuel price - diesel ($/litre)	1	1
Fuel ($/truck pa)	11,700	17,550

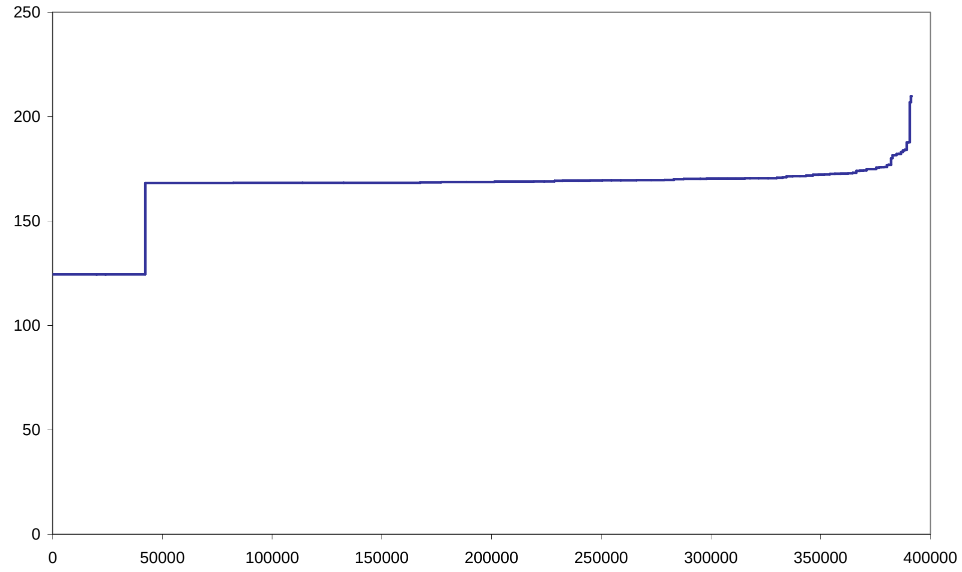
Using these estimates, total costs of kerbside recycling are shown in Table 24. These results are for a large urban setting. We vary the costs to take account of differences in population density. We have captured regional variations using the following method. We use the kms/tonne (by TA) metric calculated in the cost of collection for landfill section (4.2) to scale the cost of kerbside collection for recycling. As earlier, Auckland is used as the base case ($168/tonne). In TAs that collect recyclable waste in co-mingled form, we have used estimated costs from the table below ($125/tonne).

Table 24 Total costs of kerbside collection

	Source-segregated (Crate)		Co-mingled	
	$/truck pa	$/t	$/truck pa	$/t
Trucks	26,649	35.5	47189	39.3
Boxes/bins	10,871	14.5	51407	42.8
Labour	76,960	102.6	33,280	27.7
Fuel	11,700	15.6	17,550	14.625
Total	126,179	168	149,426	125

These base costs are adjusted reflecting household density in different locations; the resulting cost curve is shown in Figure 9. There is an initial step representing the jump from co-mingled to crate-based collection for the councils currently operating this system; thereafter the costs vary with location.

Figure 9 Kerbside collection costs



For analysis we separate out the costs of kerbside collection of the individual materials rather than using a single collection cost for each individual material. This is because we are interested in examining marginal changes, eg collection schemes with and without plastics and so on. To do this we use the density of the individual materials to produce individual collection costs for each. The resulting ranges of costs are given in Table 25.

Table 25 Collection costs ($/tonne)

Material	Co-mingled	Low	High
Mixed	125	168	210
Paper	85	94	117
Plastic	165	245	306
Glass	113	147	183
Steel	137	192	239
Aluminium	184	280	349

Collection costs for commercial waste are assumed to be the same as for household waste. This is likely to be an over-estimate of costs.

6.3. Sorting Costs

Sorting costs for the materials collected from kerbside collections vary by waste stream. The cost assumptions are shown in Table 26; this includes separate cost estimates for materials that come from crate-based and co-mingled collections.

Table 26 Sorting costs ($/tonne)

Material	Crate-based	Co-mingled
Plastics	300	400
Glass (bottle production)[1]	8	15
Glass (crushing)	5	10
Paper	40	80
Steel	15	20
Aluminium	20	25

[1] These costs do not include the costs of beneficiation

Source: industry estimates, interviews

6.4. Organic Waste (Kitchen Waste and Greenwaste)

Currently organic waste is recycled largely through households and businesses delivering garden waste to transfer stations. This is achieving approximately 312,000 tonnes per annum currently (Table 5) through drop-off of organics to community recycling centres. The analysis here examines the costs and benefits of adopting a separate kerbside collection system for organic waste.

The costs arising from a kerbside organic waste collection are likely to be similar to those with existing kerbside recycling. Estimates of kerbside collection for organic waste range around $80 - $120 per tonne.[58] This is similar to the collection costs for co-mingled collections which also use mobile bins, although organic collection would be slightly cheaper as trucks collecting organic material are likely to be able to cover a larger number of households than those collecting inorganics because organic waste can be compacted to a greater pressure.

The capital costs of setting up the greenwaste processing facility can be large enough so that it is cheaper to have large scale processing facilities with greenwaste transported from surrounding areas. For example, the Waimakariri District transports its greenwaste to Christchurch. Another set up cost that can be substantial is the resource consent process. The resulting costs for establishing a processing facility to process around 50,000 tonnes per year could be in the vicinity of $15 million – $20 million. Such a facility may have a lifespan of around 20 years and would incur maintenance and refurbishment costs.

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[58] "Regional options for Food Waste Composting", URS, June 2004 and "Trial Kerbside Collection of Household Organic Waste in Christchurch", Tony Moore, Christchurch City Council.

The operating costs of these processing facilities depend on the mix of organic waste being processed. The total operating and capital costs of processing a mix of green and kitchen waste in an enclosed indoor facility range from $70 - $170 per tonne, with an average cost being in the vicinity of $120.[59] The cost of processing only greenwaste into compost is around $50 per tonne, excluding capital costs.[60]

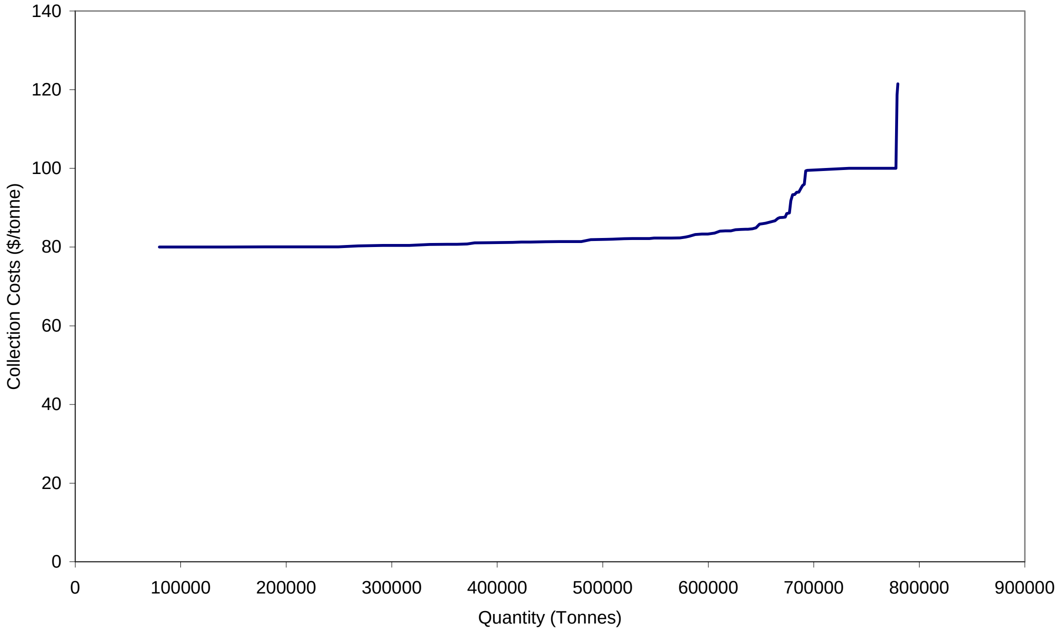
A typical cost for transporting processed compost to agricultural users is estimated to be around $10 - $15 per tonne.[61] This cost reflects the fact that a large proportion of greenwaste would be generated in cities but compost would be used largely in rural areas. Because of its high volume and relatively low value, compost is typically sold within 100 – 150 kilometres of the composting facility.[62]

Table 27 Costs of organic recycling

Costs	$/household	$/tonne
Bins (per household)	60 - 70	19 - 23
Collection		80 – 120
Processing		120
Transport		10 – 15
Total		229 - 278

As for kerbside collection costs, the collection costs for organics vary by location reflecting population densities. The results are shown in Figure 10.

Figure 10 Organic Collection Costs



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[59] Ibid and "Trial Kerbside Collection of Household Organic Waste in Christchurch", Tony Moore, Christchurch City Council, 2006.

[60] George Feitje, Living Earth Ltd.

[61] Ibid.

[62] "Regional options for Food Waste Composting", URS, June 2004.

6.5. Construction and Demolition Waste

A barrier to recovering more timber and wood products is the need for C & D waste to be manually sorted. The separation of contaminants can be difficult, as with the identification of treated versus untreated timber. On-site sorting not only incurs labour costs, which may be borne by high value tradespeople, but it also requires additional bins to store the sorted material. This can be costly, particularly on sites where the area available for such storage is limited. Alternatively, C & D waste could be sorted at transfer stations when it is delivered for disposal. An estimate of the sorting costs to segregate plasterboard from the C & D waste stream at transfer stations is $40 - $126 per tonne.[63] The cost of similar off-site sorting of wood may be within this range.

The cost of processing or chipping the wood to make it suitable as a fuel costs around $20 per tonne, although this value varies in response to moisture and ash content.[64]

Prices for crushed concrete can range from $10 - $22 per tonne, with a typical price in Auckland of around $12.70 per tonne. However, in other parts of the country, such as Canterbury, recovered concrete has much lower value given the abundance of lower-cost aggregate in the form of river gravel. For example, after the Christchurch City Council imposed a levy upon the disposal of concrete rubble and other similar material of $9 per cubic metre (approximately $6 per tonne of concrete) the disposal of this material decreased by 15%.[65] Most of this material was instead recycled, particularly concrete.

Table 28 Costs of C & D waste recycling

Costs	$/tonne
Sorting - wood	40 - 126
Chipping - wood	20
Sorting – concrete	7
Preparation - concrete	4
Crushing - concrete	8

6.6. Tyres

The major costs involved with the use of tyres as a fuel for cement kilns consist of collection and transport. The two cement kilns in the country are located in Westport (Holcim Cement) and Whangarei (Golden Bay Cement). According to Holcim Cement,[66] the cost of collecting and transporting tyres from the South Island to its kiln in Westport would be around $1.50 - $2 per tyre, which equates to a cost of around $200 - $260 per tonne.

Given the disparate distribution of tyres in the South Island and the relatively remote location of the Holcim Cement kiln, the costs of collecting and transporting tyres in the North Island to the Golden Bay Cement kiln would be lower, particularly as Auckland,

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[63] Second interim report on plasterboard recovery, Grant Emms and Bob Batenburg, 2006.

[64] James Flexman, CHH.

[65] "Review of the Operation of the Christchurch Cleanfill Bylaw 2003", Twelfth Knight Consulting, April 2005.

[66] Ibid.

which would account for around one third of the nation's end-of-life tyres, is less than two hours from Whangarei by road. The cost of transporting tyres in the North Island could be around $1 to $1.50, which is equivalent to $130 - $200 per tonne. This equates to $0.28 per tonne per kilometre. The value of tyres received by cement kilns is $104 - $136 per tonne.[67] Dumping fees may also be able to be charged for receiving the tyres, particularly where the prices charged for landfilling tyres is relatively high.

The costs of grinding tyres into large granules to be used in bitumen manufacture is estimated at $120 per tonne. On top of this, the cost of collecting and transporting tyres to grinding plants is likely to be similar to the costs of transporting tyres to cement kilns. Although the transport costs could be reduced by shredding tyres, which reduces the volume of tyres by around 75%, the shredding process itself would imposes costs. As noted above, it is not certain that this would be financially advantageous over existing production techniques.

Table 29 Costs of recycling tyres

Costs	$/tonne
Collection – North Island	130 – 200
Collection – South Island	200 – 260

6.7. Used oil

The collection and transportation constitute the bulk of the costs associated with recycling used oil. These costs were estimated to be $0.15 per litre for urban areas and $0.20 per litre for rural areas, with oil distributed around the country roughly proportionally to population.[68] Assuming that the costs of transportation have increased by around 15 – 20% since 2001, based largely upon higher fuel prices,[69] the costs of collection are estimated to now be approximately $0.18 per litre to $0.23 per litre. These costs also include some processing costs as contaminants in the used-oil, such as water, need to be drained before it is suitable to be used as fuel. This cost does not include the cost of shipping the collected oil from various ports around the country to Holcim's cement kiln.

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[67] This is based upon an energy content of 26 – 34 GJ per tonne.

[68] "Options for Used Oil Recovery in New Zealand", PA Consulting Group, August 2001.

[69] New Zealand Energy Data File, September 2006, www.med.govt.nz/energy/info/

7. Net Benefits of Recycling

This section summarises the results of the analysis and the comparison of costs and benefits. The initial set of figures is presented using a 10% discount rate. Sensitivity analysis is undertaken at a 5% rate.

The quantity input data used in analysis are shown in Table 30. The recovered percentage is the quantity currently recovered for recycling; the technically recoverable is an assumption based on what is achievable given the methods of collection that are used to derive the costs.

Table 30 Recyclable material quantities

	Generated (tonnes)	Recovered (tonnes)	Recovered (%)	Technically recoverable (%)	Technically recoverable (tonnes)
			Household		
Paper	299,625	200,893	67%	75%	224,719
Plastic	42,303	30,114	71%	75%	31,727
Metal	31,029	15,793	51%	85%	26,375
Glass	127,841	71,069	56%	85%	108,665
Organic	415,764	195,620	47%	85%	353,399
Sub-Total	916,563	513,489	56%	81%	744,886
			Commercial		
Paper	391,751	254,000	65%	75%	293,814
Plastic	185,709	9,000	5%	55%	102,140
Metal	620,574	500,000	81%	85%	527,488
Glass	50,236	17,767	35%	85%	42,700
Organic	497,050	116,465	23%	85%	422,492
Sub-Total	1,745,320	897,232	51%	80%	1,388,634
			Other		
C&D (tonnes)	2,835,000	1,000,000	35%	80%	2,268,000
Used Oil (litres)	40,000,000	24,000,000	60%	80%	32,000,000
Tyres (UEPUs)[1]	4,000,000	0	0%	80%	3,200,000

[1] Used Equivalent Passenger Units — a way to aggregate many tyres of different sizes

The analysis for each material uses three sets of assumptions:

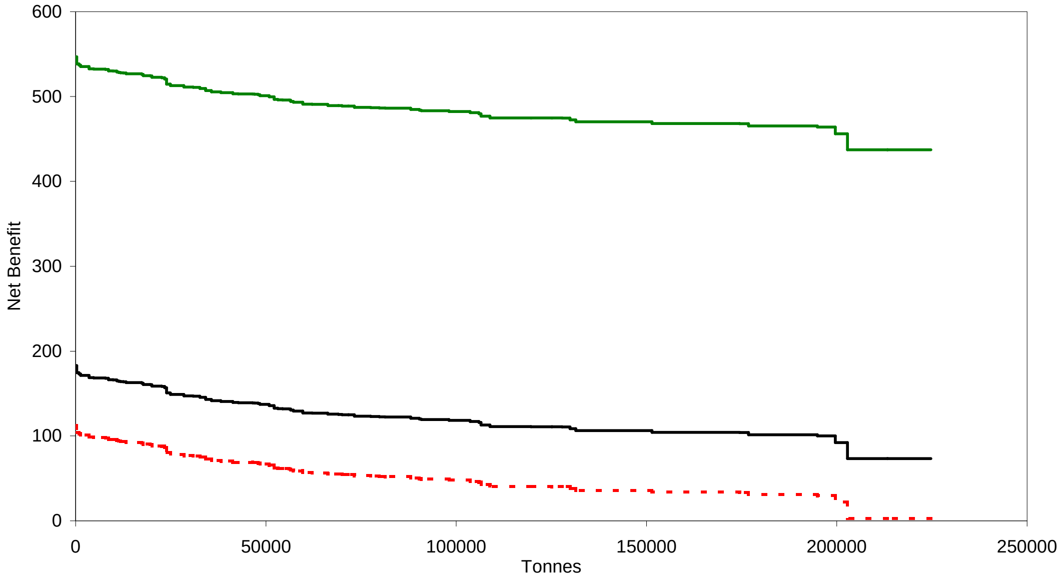
- an initial rate of recycling based on benefit estimates that include savings in landfill costs (social cost estimate rather than a market rate) but ignore external costs associated with emissions, leachate and the direct consumer benefits
- a low benefit estimate that uses the low assumptions from Table 19
- a high benefit estimate that uses the high assumptions from Table 19.

Under each material in the following pages, the net costs or net benefits of recycling that material stream is shown. In each case the y-axis represents the marginal net benefits (or net costs when the line goes below zero) of recycling successive amounts of a given material; the x-axis represents the cumulative quantity of material recycled up to a total equal to the technically recoverable quantity. This is equivalent to the aggregate amounts in household, commercial and other waste streams in Table 30.

7.1. Paper

The net benefits of recycling household paper are shown in Figure 11. In Figure 11 there are positive net benefits for recycling 225,000 tonnes of household paper under all assumptions.

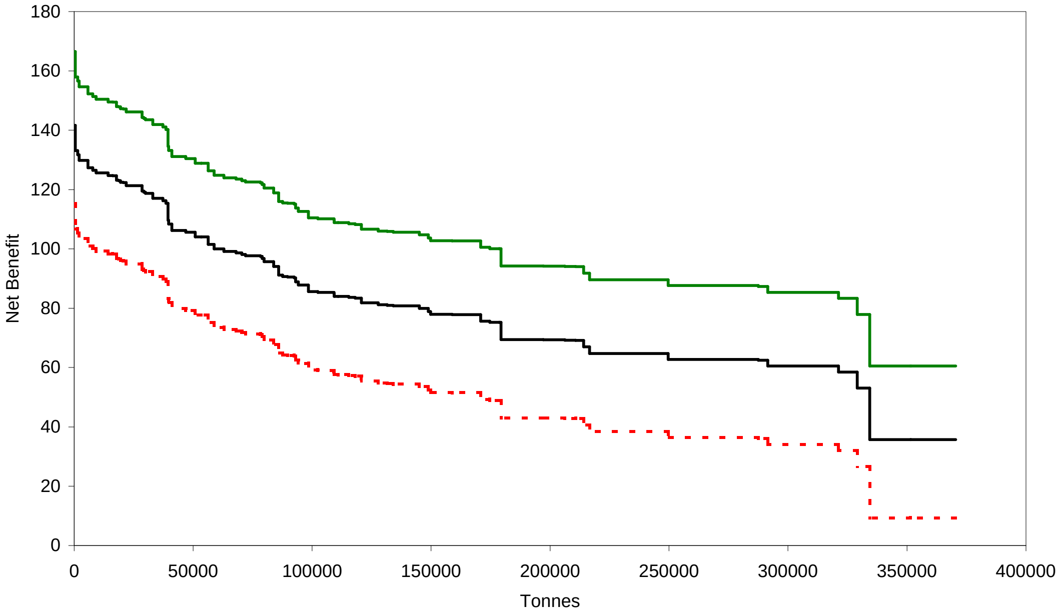
Figure 11 Net benefits ($/tonne) of recycling household paper



Dotted line = no externalities included; solid lines: high and low benefit estimates

Figure 12 shows the net benefits of recycling commercial paper. The analysis of costs is undertaken such that all current systems have net benefits; these systems occur under commercial contracts and, by definition there will be positive (or at least zero) net benefits.

Figure 12 Net benefits ($/tonne) of recycling commercial paper

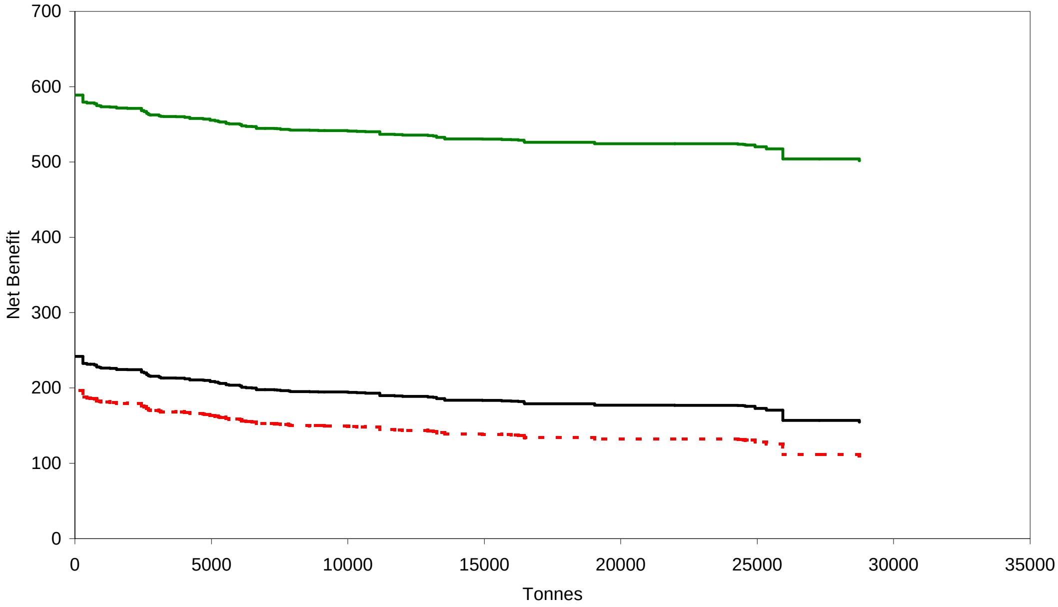


Dotted line = no externalities included; solid lines: high and low benefit estimates

7.2. Plastics

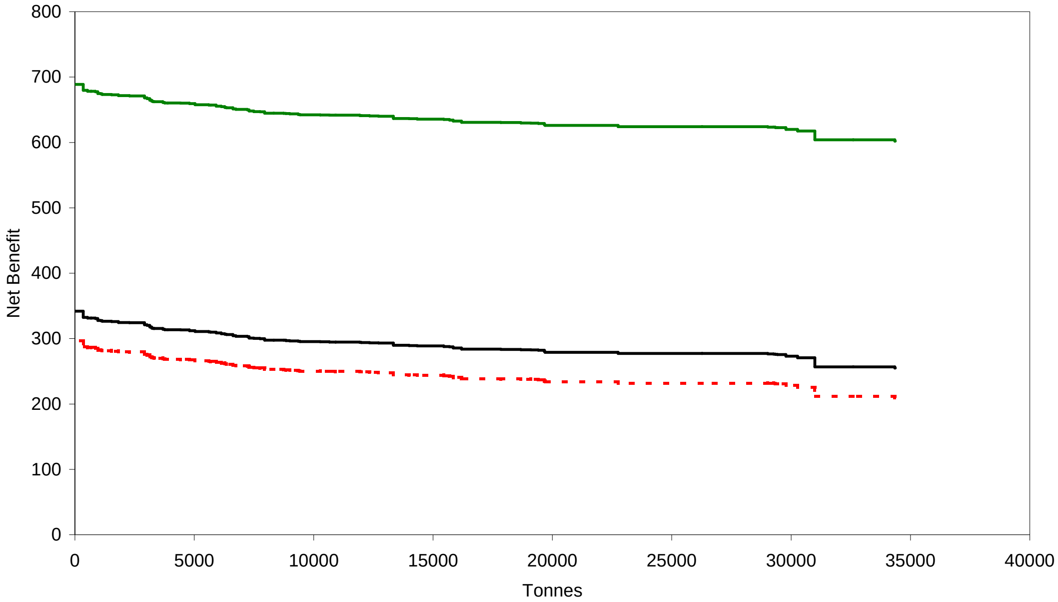
The net benefits of recycling individual plastic streams are shown in the following charts. There are positive net benefits for recycling PET and HDPE for all quantities that are recoverable.

Figure 13 Net benefits ($/tonne) of recycling PET



Dotted line = no externalities included; solid lines: high and low benefit estimates

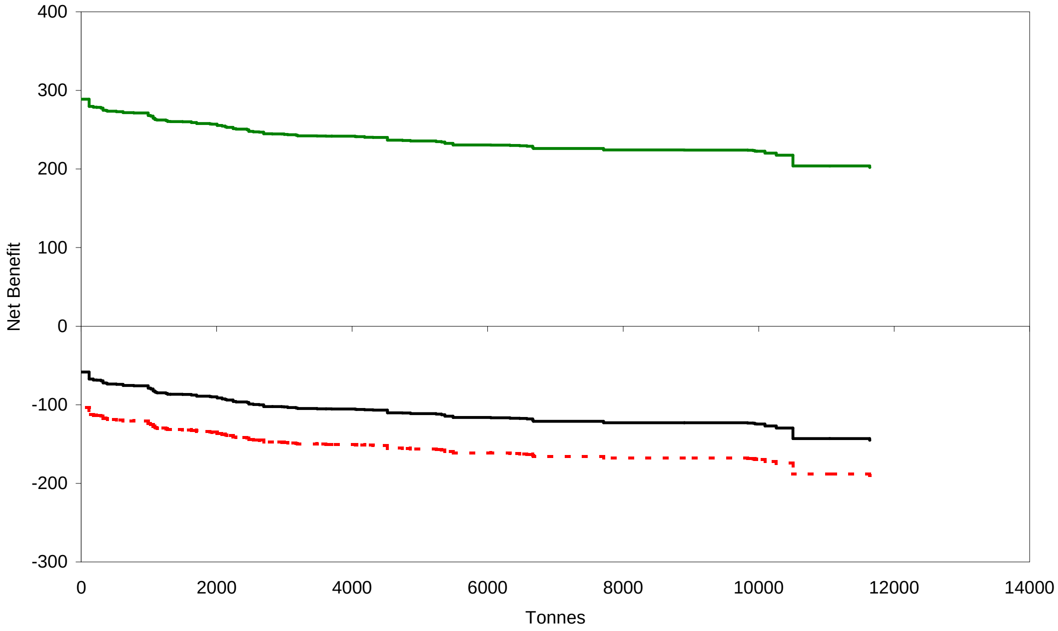
Figure 14 Net benefits ($/tonne) of recycling HDPE



Dotted line = no externalities included; solid lines: high and low benefit estimates

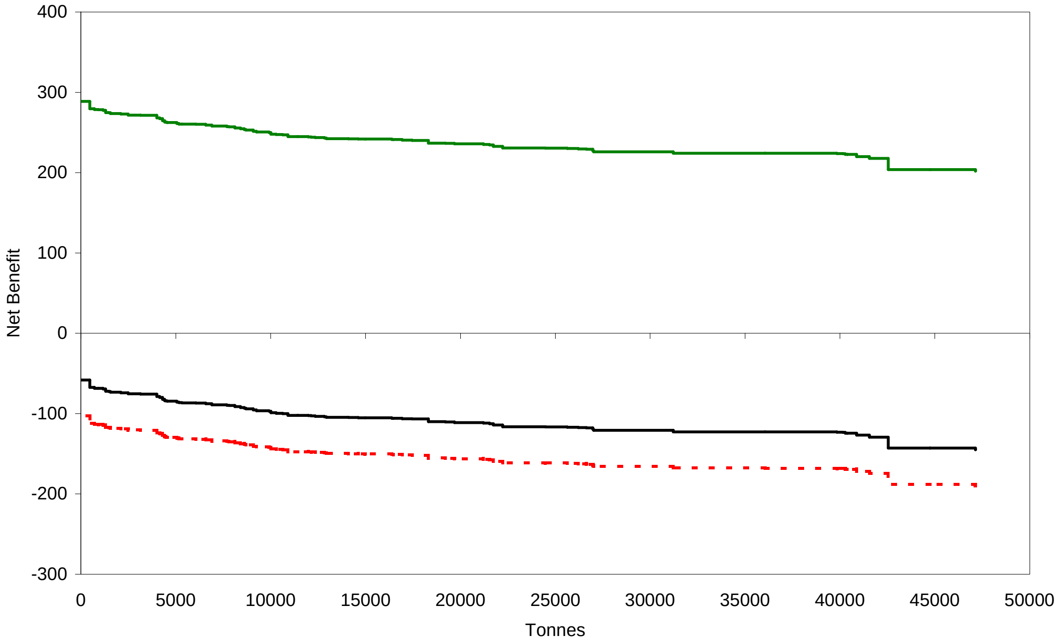
For PVC and LDPE, the value of recycling depends crucially on the estimates made of the value of external benefits and particularly the direct consumer benefits.

Figure 15 Net benefits ($/tonne) of recycling PVC



Dotted line = no externalities included; solid lines: high and low benefit estimates

Figure 16 Net benefits ($/tonne) of recycling LDPE

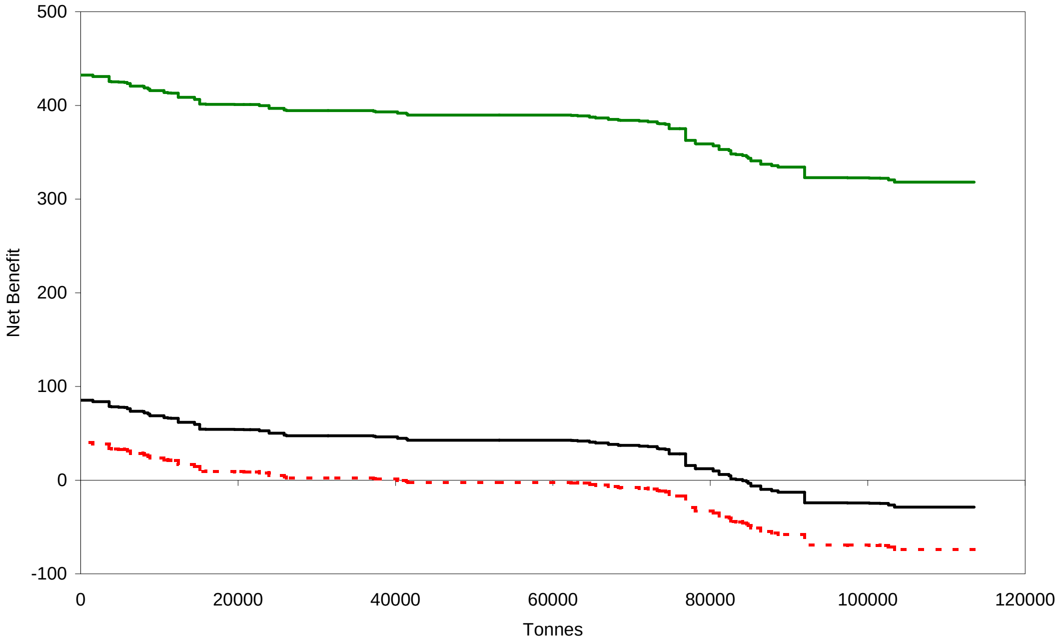


Dotted line = no externalities included; solid lines: high and low benefit estimates

7.3. Glass

The net benefits of recycling coloured glass are shown in Figure 17 and clear glass in Figure 18. The recycling of these materials is limited by the capacity (70,000 tonnes) at OI and the low value in other uses (assumed to be zero).

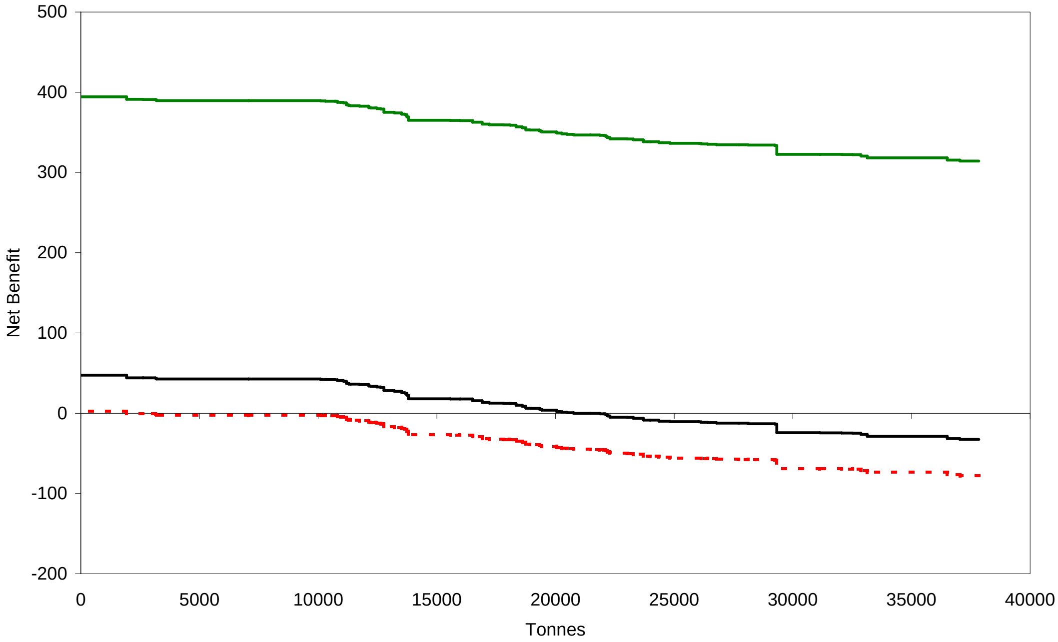
Figure 17 Net benefits ($/tonne) of recycling coloured glass



Dotted line = no externalities included; solid lines: high and low benefit estimates

The results of the analysis for clear glass are shown in Figure 18. The O-I capacity is assumed to be 10,000 tonnes; beyond this clear glass is assumed to have a market value of zero.

Figure 18 Net benefits ($/tonne) of recycling clear glass

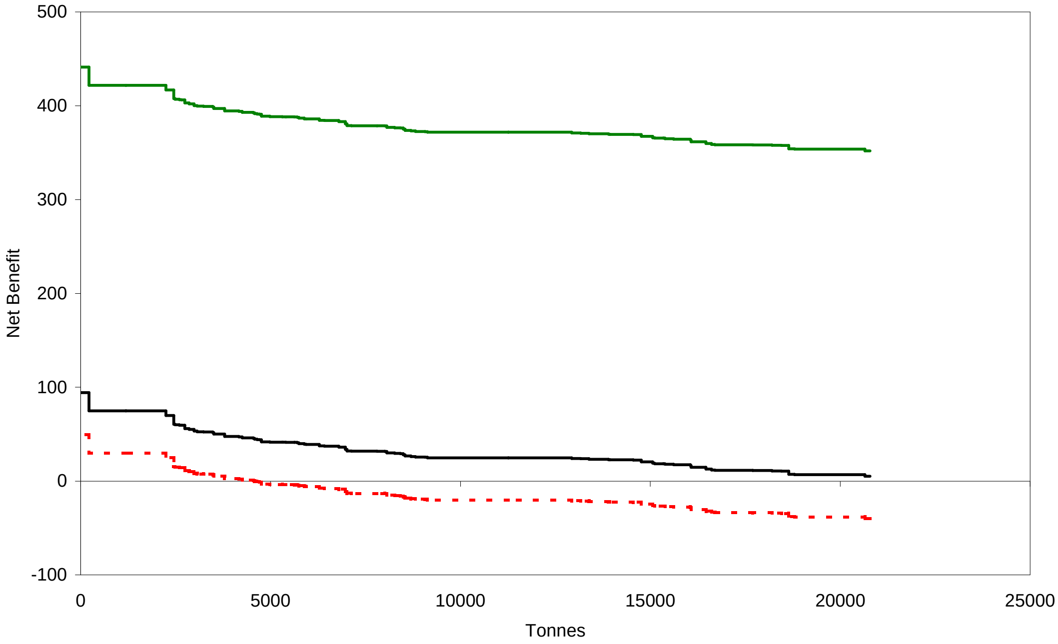


Dotted line = no externalities included; solid lines: high and low benefit estimates

7.4. Metals

Figure 19 shows the net benefits of recycling steel. Above approximately 6,000 tonnes, recycling is justified when account is taken of the external benefits (direct consumer benefits).

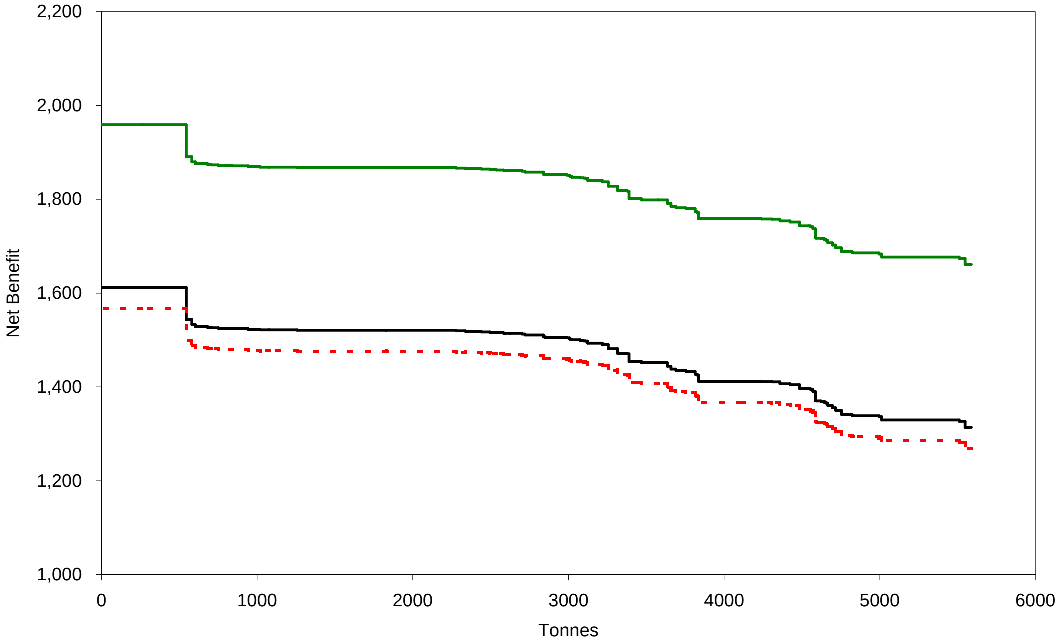
Figure 19 Net benefits ($/tonne) of recycling steel



Dotted line = no externalities included; solid lines: high and low benefit estimates

Recycling of all aluminium containers provides net benefits even without the inclusion of external benefits (Figure 20).

Figure 20 Net benefits ($/tonne) of recycling aluminium

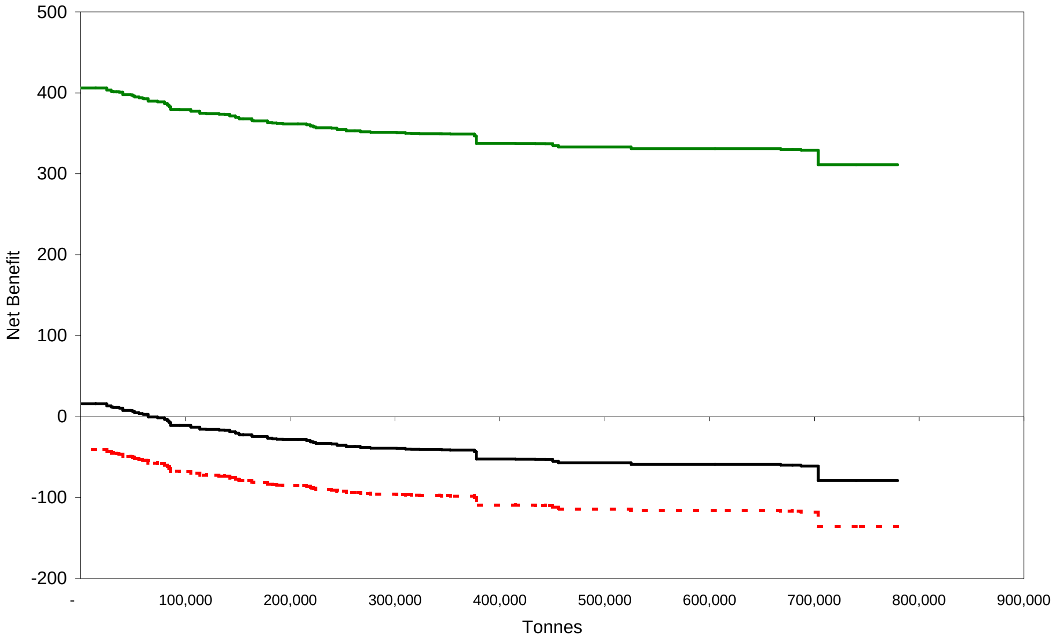


Dotted line = no externalities included; solid lines: high and low benefit estimates

7.5. Organics

The net benefits of recycling organics are shown in Figure 21. These results need to be interpreted carefully; the analysis suggests that up to approximately 200,000 tonnes can be recycled at a net benefit including low benefit values, although this is less than is currently recovered (Table 30). The difference results from different assumptions regarding collection method. The analysis here assumes a separate kerbside collection system for organics rather than the drop-off system that is currently used; such a system appears to be justified only under the high benefit value estimates (see Table 19 on page 28).

Figure 21 Net benefits ($/tonne) of recycling organics



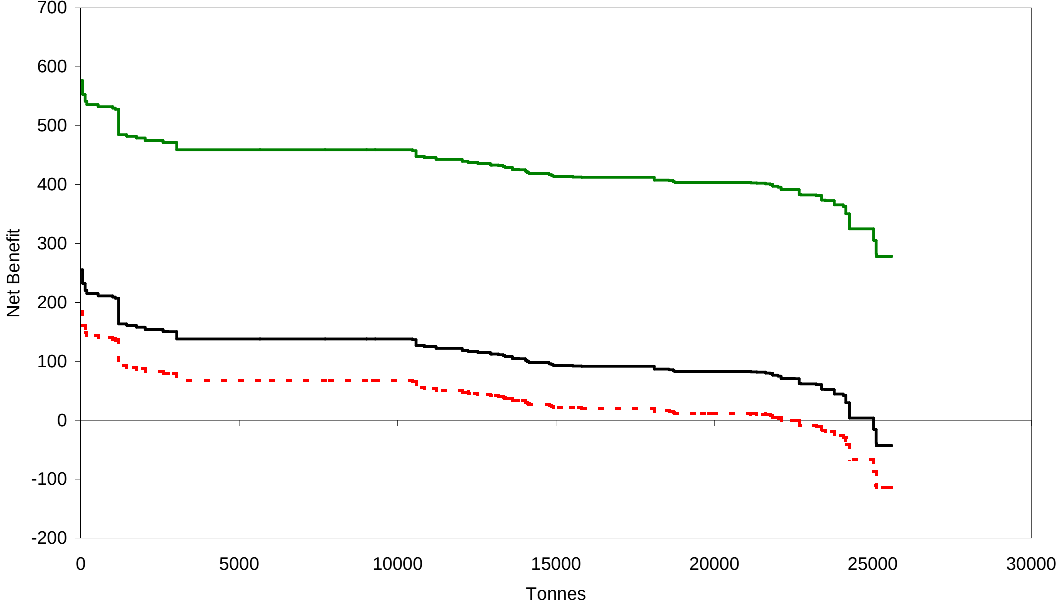
Dotted line = no externalities included; solid lines: high and low benefit estimates

7.6. Tyres

The net benefits of recycling end-of-life tyres are shown in Figure 22.

The analysis suggests a significant quantity could be recycled at a net benefit, even in the absence of the external benefits.

Figure 22 Net benefits ($/tonne) of recycling end-of-life tyres

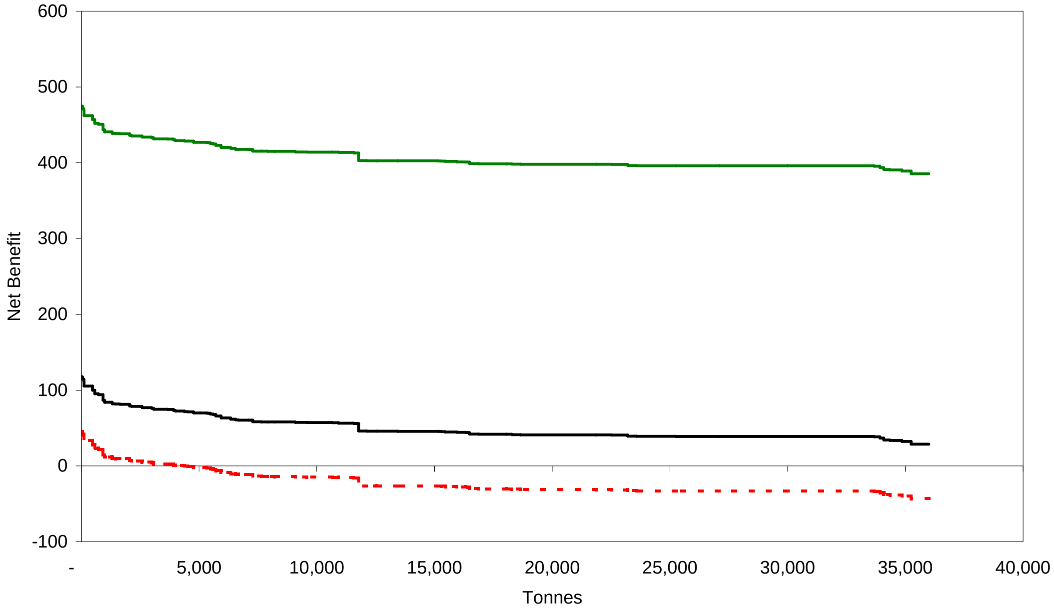


Dotted line = no externalities included; solid lines: high and low benefit estimates

7.7. Used Oil

The net benefits of recycling used oil are shown in Figure 23. The inclusion of direct benefits increases substantially the estimate of the quantities that can be recycled at a net national benefit.

Figure 23 Net benefits ($/tonne) of recycling used oil



Dotted line = no externalities included; solid lines: high and low benefit estimates

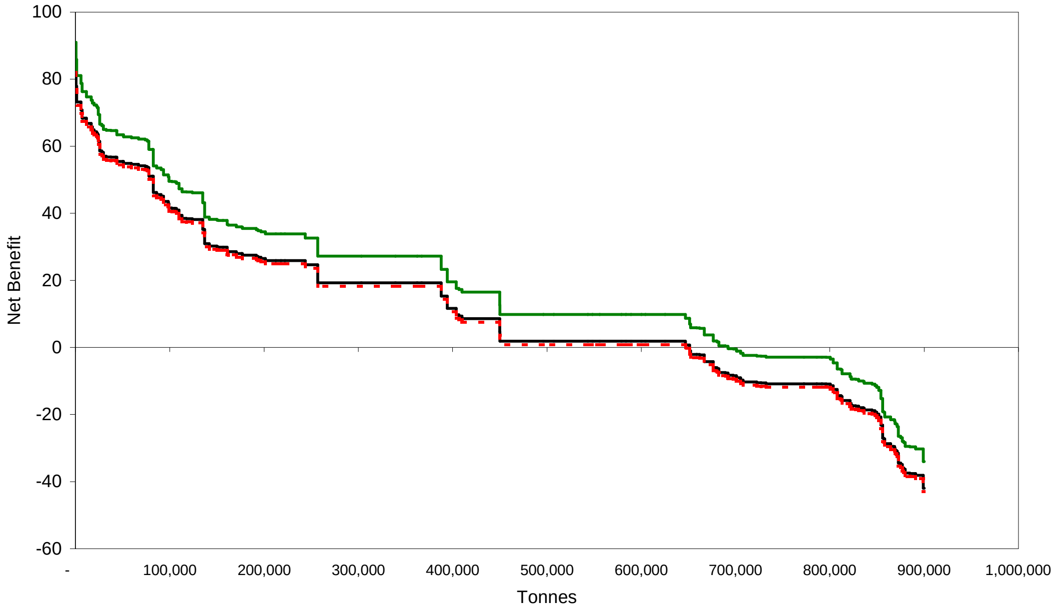
7.8. Construction and Demolition Waste

The net benefits of recycling construction and demolition waste are estimated below for the two streams—concrete & rubble and timber.

For concrete & rubble there are few external benefits – only those associated with landfill disamenity and these provide little additional benefit. There are positive net benefits from recycling 650,000-700,000 tonnes.

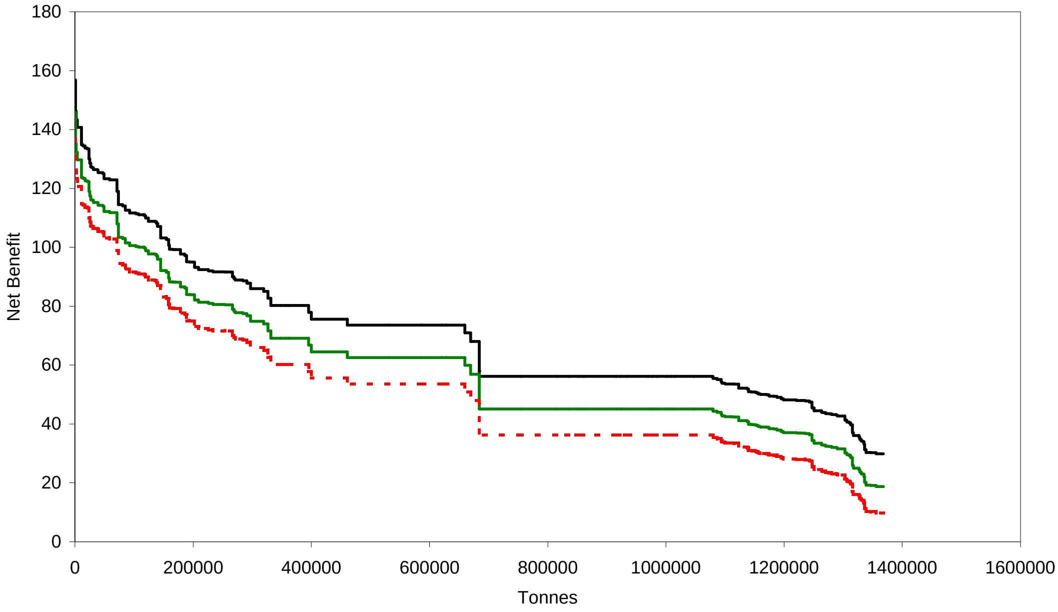
For timber waste, there are estimated net benefits from savings in greenhouse gas emissions in addition to the savings in disamenity impacts. However, the estimates are that there are substantial private benefits from recycling timber waste because of its value as an energy fuel.

Figure 24 Net benefits ($/tonne) of recycling concrete & rubble



Dotted line = no externalities included; solid lines: high and low benefit estimates

Figure 25 Net benefits ($/tonne) of recycling wood from construction waste



Dotted line = no externalities included; solid lines: high and low benefit estimates

7.9. Summary

The results are summarised in Table 31 and Table 32. It shows the total quantity generated, that technically recoverable using current technologies, that currently recovered and quantities that could be recycled for each material with positive net benefits under high and low benefit assumptions. It shows the results at two discount rates: 5% and 10%.

Table 31 Summary of results—recoverable, currently recovered and quantities that could be recycled with positive net benefits ('000 t)

	Generated	Technically recoverable	Currently Recovered	Low Benefit Values		High Benefit Values	
				10%	5%	10%	5%
	'000 t	'000 t	'000 t	'000 t	'000 t	'000 t	'000 t
Paper – household	300	225	201	225	225	225	225
Paper – commercial	494	370	254	370	370	370	370
Plastic - PET	49	29	8	29	29	29	29
Plastic – HDPE	59	34	9	34	34	34	34
Plastic – PVC	20	12	3	-	-	12	12
Plastic - LDPE	81	47	13	-	-	47	47
Glass- Coloured	134	114	67	84	85	114	114
Glass -Clear	45	38	22	21	22	38	38
Steel	24	21	12	21	21	21	21
Aluminium	7	6	3	6	6	6	6
Organics	917	780	312	64	84	780	780
Tyres	32	26	-	25	25	26	26
Used Oil	36	36	22	36	36	36	36
Concrete	1,125	900	397	651	651	692	692
Timber	1,710	1,368	603	1,368	1,368	1,368	1,368
Total	5,031	4,004	1,926	2,934	2,957	3,796	3,796

Table 32 Summary of results— recoverable, currently recovered and quantities that could be recycled with positive net benefits (%)

	Technically recoverable	Currently Recovered	Low Benefit Values		High Benefit Values	
			10% d.r.	5% d.r.	10% d.r.	5% d.r.
	%	%	%	%	%	%
Paper – household	75	67	75	75	75	75
Paper – commercial	75	51	75	75	75	75
Plastic - PET	58	16	58	58	58	58
Plastic – HDPE	58	16	58	58	58	58
Plastic – PVC	58	16	0	0	58	58
Plastic - LDPE	58	16	0	0	58	58
Glass- Coloured	85	50	63	64	85	85
Glass -Clear	85	50	47	50	85	85
Steel	85	51	85	85	85	85
Aluminium	85	51	85	85	85	85
Organics	85	34	7	9	85	85
Tyres	80	0	78	78	80	80
Used Oil	100	60	100	100	100	100
Concrete	80	35	58	58	62	62
Timber	80	35	80	80	80	80
Total	80	38	58	59	75	75

d.r. = discount rate

8. Conclusions

The analysis suggests that there is the potential to increase rates of recycling at a positive net benefit for nearly all waste streams. The only exceptions to this are PVC, LDPE and organics for which, under low benefit estimates, the results suggest that recycling rates are currently higher than optimal. For organics, it should be noted that the analysis of costs assumes a different collection methodology from that used currently. Specifically, the analysis assumes that kerbside collection of organic material is used rather than the current drop-off system. Therefore the results cannot be used to conclude that current rates of recycling of organics are too high, but rather that switching to the different collection method is justified only under the high benefit value assumptions.

Clear glass shows net benefits of collecting close to current rates, although the estimates of current rates ignore the fact that considerable quantities are being stockpiled awaiting the identification of suitable markets. The analysis here suggests it is worthwhile collecting some of this material for low (zero) value markets.

The contributing factors to the net benefits vary by material, but where they are included (household waste, including organics, end-of-life tyres and used oil), direct consumer benefits, estimated from a willingness to pay study undertaken in parallel with this study, are the most significant contributing factor to total benefits. These are potentially the most contentious elements of the analysis partly because, to our knowledge, such estimates have not been included in other recycling cost benefit analyses. However, the legitimacy of this benefit seems clear.

Willingness to pay studies can over-estimate benefits because people can over-state their willingness to pay when they do not believe that they will actually have to pay or they do not fully understand the payment mechanism. This is tackled to some extent through the inclusion of questions about willingness to spend time in addition to willingness to pay financially. However, there remains a degree of uncertainty regarding the size of these benefit estimates. This is so also because there is uncertainty over whether the respondents assumed that their willingness to spend time related to the current quantity of material collected or to an increased volume, for which there would be a requirement for additional time to be spent. The range of values used takes account of this uncertainty and the values are still sufficiently high to provide significant additional benefits of recycling. There would be value in further research into the willingness to pay values to better understand the assumptions being made by households.

Taking the full set of benefits into account, the results suggest that increasing rates of recycling in New Zealand is justified across all assumptions, for the majority of materials examined. Consistent with this, least cost instruments to achieve higher rates of recycling should be examined.

Annex 1 Landfill Assumptions

Location	Capacity (tonnes/annum)	Cost of disposal ($/tonne)
Kaikohe	50,000	98
Whangarei	80,000	75
Warkworth	520,000	25
Auckland	450,000	27
Pukekohe	450,000	27
Paeroa	55,000	93
Ngaruawahia	130,000	57
Te Awamutu	110,000	63
Tokoroa	70,000	81
Tauranga	135,000	56
Whakatane	35,000	119
Taupo	50,000	98
Gisborne	45,000	104
Wairoa	25,000	143
Napier	65,000	85
Hastings	65,000	85
Waipawa	25,000	143
Taumarunui	30,000	130
New Plymouth	70,000	81
Wanganui	80,000	75
Taihape	35,000	119
Palmerston North	95,000	68
Masterton	75,000	78
Paraparaumu	90,000	71
Wellington	220,000	42
Wellington	315,000	34
Blenheim	50,000	98
Nelson	65,000	85
Takaka	35,000	119
Westport	25,000	143
Greymouth	25,000	143
Hokitika	25,000	143
Haast	25,000	143
Amberley	30,000	130
Christchurch	380,000	30
Temuka	65,000	85
Oamaru	30,000	130
Ranfurly	25,000	143
Alexandra	25,000	143
Queenstown	25,000	143
Dunedin	140,000	55
Balclutha	30,000	130
Invercargill	120,000	60

Annex 2 Willingness to Pay Survey

Study ID	1402-06	(101-106)	Resp. No.	
Interviewer No.		(114-117)	Interview Length	
No. Of Queries		(120-121)	Reference No.	

ACNielsen

Name of respondent: ________________

Name of company: _________________

Telephone No.: ____________________

Interviewer no.: ____________________

Date of interview: ___________________

Time began: _______________________

Time ended: _______________________

Hello!

Q1 MA

How do you currently pay for your rubbish collection?

- Buy official rubbish bags or labels
- Pay for a separate service with a collection company
- Pay for it in your rates or rent
- Other (please specify)
- Don't know

Q2 Duplicate this question with response order from high to low

How much time does your household currently spend weekly in sorting, cleaning, and organising materials for recycling over and above the time that you would spend if only putting it in the (non-recycled) rubbish?

Less than 3 mins per week ....

3 mins per week ....

5 mins per week ....

10 mins per week ....

20 mins per week ....

30 mins per week ....

40 mins per week ....

Don't recycle ....

Other (Please specify) ....

Don't know ....

Q3 Duplicate this question with response order from high to low

What is the maximum time your household would be willing to spend weekly in sorting, cleaning, and organising materials for recycling over and above the time that you would spend if only putting it in the (non-recycled) rubbish?

Less than 3 mins per week ....

3 mins per week ....

5 mins per week ....

10 mins per week ....

20 mins per week ....

30 mins per week ....

40 mins per week ....

Other (Please specify) ....

None ....

Don't know ....

Q4 Duplicate this question with response order from high to low

If you had to pay for your household’s recycling of plastics, paper and glass as a separate charge, how much would it be worth to you to ensure they were recycled in an environmentally responsible way?

20c per week

50c per week

$1 per week

$2 per week

$3 per week

$4 per week

$5 per week

$6 per week

$7 per week

Wouldn't pay

Other (please specify)

Don't know

Q5 Duplicate this question with response order from high to low

If you could not do it yourself and had to pay for your own composting as a separate charge, how much would it be worth to you to ensure your household’s garden and kitchen waste was recycled in an environmentally responsible way?

20c per week

50c per week

$1 per week

$2 per week

$3 per week

$4 per week

$5 per week

$6 per week

$7 per week

Wouldn't pay

Other (please specify)

Don't know

Q6 Duplicate this question with response order from high to low

How much is it worth to you to ensure that, when you change a tyre on your car, the used one is recycled in an environmentally responsible way?

20c per tyre ....

50c per tyre ....

$1 per tyre ....

$2 per tyre ....

$3 per tyre ....

$4 per tyre ....

$5 per tyre ....

$6 per tyre ....

$7 per tyre ....

Wouldn't pay ....

Other (please specify) ....

Don't know ....

Q7 Duplicate this question with response order from high to low

How much is it worth to you to ensure that when you, or your garage, change your car oil, the used oil is recycled in an environmentally responsible way?

20c per oil change ....

50c per oil change ....

$1 per oil change ....

$2 per oil change ....

$3 per oil change ....

$4 per oil change ....

$5 per oil change ....

$6 per oil change ....

$7 per oil change ....

Wouldn't pay ....

Other (please specify) ....

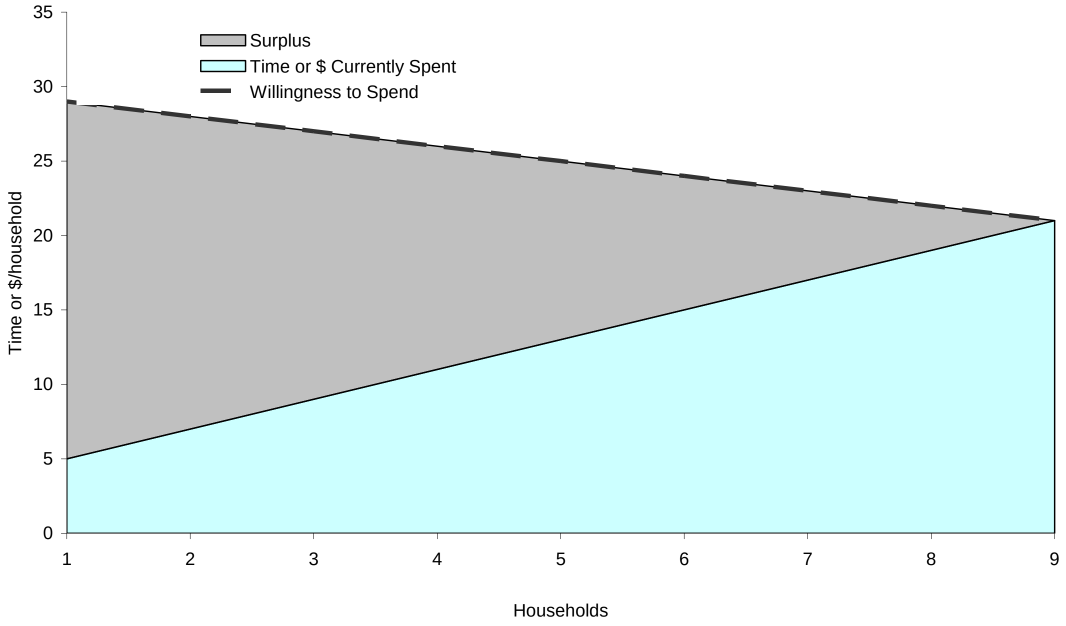
Don't know ....

Annex 3 Analysis of Willingness to Pay Results

Obtaining consumer surplus from the survey

An analysis has been conducted in parallel with the cost benefit analysis to estimate if there are direct consumer benefits associated with recycling. The direct consumer benefits are measured as consumer surpluses from the willingness to spend time or money recycling above the time actually spent (Figure 26).

Figure 26 Consumer Surplus from Recycling



A survey was undertaken by AC Nielsen. It was conducted using the Nielsen Online Omnibus that covers 1,000 interviews with people aged 18 and over; it used a "payment card" approach. A national sample is selected and results are weighted (by age, gender, region, internet access and frequency) to reflect the NZ population. Interviews were completed online between the 23rd and 30th of January 2007. It asked respondents about the time they currently spend and are willing to spend. It also asked how much it was worth to respondents to have their waste recycled (their willingness to pay), for four different forms of waste – plastics, paper and glass (PP&G), garden and kitchen waste (organics), car tyres, and car oil.

There is some overlap between the willingness to pay (WTP) questions and the willingness to spend time (WTST) questions. For PP&G, the WTP question implies a cost on top of the time taken to organise it. However, the WTST question suggests the extra time might be spent on further sorting and organising. While the WTP seems largely on top of current time spent, it is possible that respondents considered extra payment and extra time as substitutes. The organics question supposes that households cannot do their own composting. For those that compost, this then implies a payment instead of time spent. But for those that don't compost, it implies a cost on top of sorting this waste. Car tyres and oil were not the type of item implied in the time questions, and so these questions imply a cost without any time spent (indeed, most people do not spend any time recycling their tyres and oil).

Therefore, we must be careful not to interpret total surplus as the sum of the two channels. Some respondents may have considered extra time and extra money spent as substitutes (at least to some degree), and if this is the case then total surplus will be less than the sum of surplus from time and money. Usefully this means that the money question might also be used to estimate the value of time spent recycling.

In what follows we investigate the consumer surplus derived from time saved.

Survey figures

Time

For analysis, where results were stated as "Less than 3 minutes" in survey questions 2 and 3, we have assumed a value of 1.5 minutes.

On average respondents estimate that they spend 13.6 minutes per week recycling, but would be willing to spend 23.4 minutes.

Females spend more time and are more willing to spend time than males. These differences are both statistically significant (at the 10% level). 40-54 year olds are willing to spend more time recycling than those younger, with 25-39 year olds also more willing than their juniors (all statistically significant).

There is no significant difference between the four regions of the country with regard to time spent or willingness to spend time, or between those working full- and part-time. Any difference with regard to income levels is unclear. There is evidence that those earning \$20k-\$39k are more willing to spend time than those earning \$40k-\$59k and \$80k+, but this is not the case for \$60k-\$79k.

Willingness-to-pay

On average people state that they would be willing to spend \$1.68 per week to recycle their PP&G, \$1.50 per week to recycle their organics, \$2.22 to recycle one car tyre, and \$2.10 to recycle their car oil each time it gets changed.

Those aged 25-39 are least willing to pay to recycle PP&G and organics. Those aged 55 and above are willing to pay the most for organics and car tyres, but this is not the case for PP&G. There are no significant differences with regard to oil.

There are no significant regional variations in willingness-to-pay for PP&G or oil, but some evidence for the other two categories. The 'North' region is willing to pay more for organics than the 'South' or 'Central' regions, while 'North' and Auckland are willing to pay more to recycle tyres than the 'South' region (significance at 10% level).

There is no evidence of differences between full-time, part-time workers or those without a job.

There are no significant income differences for recycling PP&G. For car tyres and oil, those earning $20k-$39k and those on $80k+ are willing to pay more than those earning other amounts, while there is similar (but weaker) evidence for this with organics.

Value of time

As outlined above, the average respondent was willing to spend longer recycling than they did currently. To convert this time into monetary equivalent requires an estimate of the value of a person's time.

We estimate that when a person spends time recycling (the time spent sorting waste and placing in the correct bin or similar, over and above that which would be spent if all waste was just put in the rubbish) the value of that time is $5.20 per hour. This estimate is based on the Land Transport New Zealand's Economic Evaluation Manual. Table 33 shows the values outlined in the manual which has estimates of the value of reduced travel time.

The values for non-work purposes are most applicable to the analysis. When people recycle they are using time which they would otherwise spend doing things around their home, and generally people do not work less because they spend a short period of time recycling. A value of $5.20 is used as a reasonable intermediate value from the different transport types.

Table 33 Value of travel time saved—base values for vehicle occupant time in $/h

Vehicle occupant	Work travel purpose	Commuting to/from work	Other non-work travel purposes
Car, motorcycle driver	23.85	7.80	6.90
Car, motorcycle passenger	21.70	5.85	5.20
Light commercial driver	23.45	7.80	6.90
Light commercial passenger	21.70	5.85	5.20
Medium/heavy commercial driver	20.10	7.80	6.90
Medium/heavy commercial passenger	20.10	5.85	5.20
Seated bus and train passenger	21.70	4.70	3.05
Standing bus and train passenger	21.70	6.60	4.25
Pedestrian and cyclist	21.70	6.60	4.25

Source: Land Transport New Zealand, 2006. Economic Evaluation Manual – Volume 1

Calculating consumer surplus

Household inorganic recycling

The survey shows that, on average, people are willing to spend more time recycling than they already spend. This implies that people are receiving a net benefit from recycling—a consumer surplus. This surplus varies between people.

Willingness to Spend Time

To calculate the consumer surplus for each individual, we subtract the time currently spent recycling from that which they are willing to spend.

Some people stated that they are willing to spend a period of time recycling which is less than they currently spend, implying a negative surplus. These responses might be explained by people recycling not because they gain direct utility from it, but because they wish to avoid disutility in the form of guilt and scorn from neighbours etc. We have used a value of zero for these surpluses (rather than negative); there is no requirement to recycle but these people are willing to spend time (they currently do), to avoid disutility.

The average consumer surplus is 10.1 minutes per week[70], which translates into $0.88 per household per week (using the value-of-time factor of $5.20/hr).

In estimating a willingness to pay per tonne of waste, one of the key issues is the appropriate denominator. There are a number of possibilities (Table 34). The mid-value ($183/tonne) assumes that the willingness to pay or spend additional time relates to the existing volume of collected material. The high value assumes that an additional amount (2.3kg) was collected but would take no additional time. The low value assumes that the willingness to pay/ spend time relates to the total inorganic recyclable volume but that collecting the additional quantity (2.3kg) takes proportionally the same amount of time as collecting the existing volume.

Table 34 Value of household recycling

Categories of waste	Kg/household/week
a) Inorganic waste currently recycled by households with weekly collections	4.8
b) Inorganic waste not currently recycled but could be	2.3
Denominator	**$/tonne**
Low (a + b = 7.1)	44
Medium (a)	183
High (b)	383

The resulting range of values is $44-383/tonne as a direct value to consumers of recycling, with a medium value of $183/tonne based on 4.8kg. The survey also found that people were willing to pay $1.68/week to recycle PP&G, which implied a surplus of $350/tonne (based on 4.8 kg per week), [71] thus the values used above are likely to be conservative.

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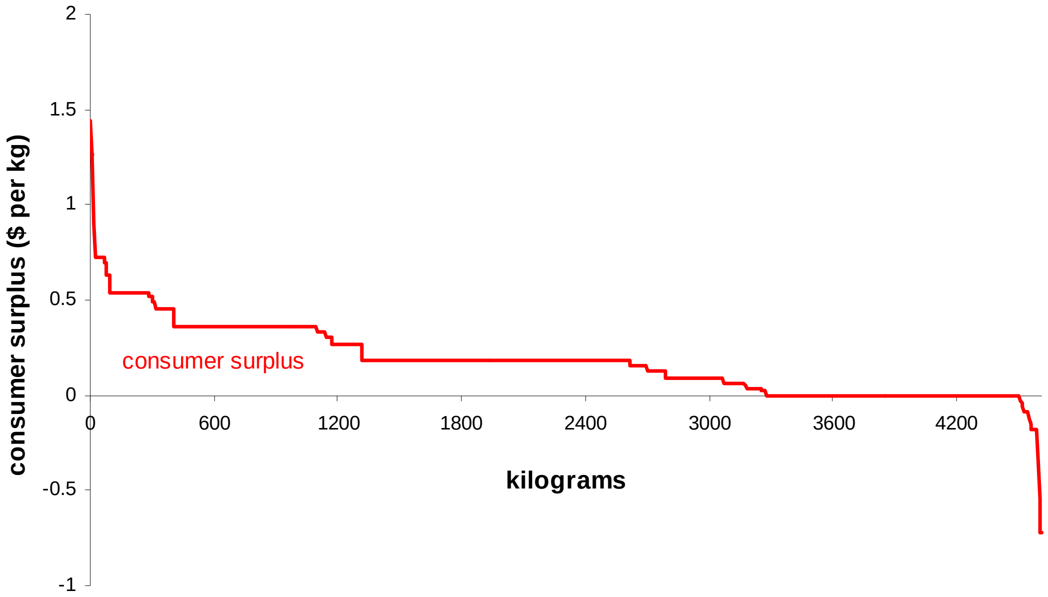
[70] Note that this is not equal to the difference of the average time spent and time willing to be spent as quoted earlier. This figure considers those with negative surplus to have zero surplus, and also only calculates surplus values for respondents who gave numerical answers for both questions (many only gave one). 10.1mins is the average surplus (difference between time willing to be spent and time currently spent) for those who gave numerical answers to both questions, assuming zero surplus for those who stated they have negative surplus.

[71] If we use this stated willingness to pay as a substitute for time, then the suggested value of time in recycling is $9.98/hour

Figure 26 drew each line sloping in one direction as if each person had their time ranked. But the person (or kg) with the highest willingness to pay is not necessarily the same person who spends the least – thus the first kg in Figure 1 is not necessarily the same person on each line. In order to model the surplus from survey respondents we have to calculate the surplus for each person and show this as a single (net) line.

The survey had 1004 respondents. We discarded those who responded "Don't know" for any question which we needed a value for, which left us with a sample size of 961 people. At 4.8kg/week this meant about 4613kg. Figure 27 shows the consumer surplus for the individuals in our sample. The area between the line and the horizontal axis is the total consumer surplus for these respondents.

Figure 27: Consumer surplus of surveyed respondents



Willingness to pay

On average, respondents said they were willing to pay $1.68 per household per week to recycle their PP&G. People do not currently pay directly to recycle these items, but do so through their rates, if they pay at all. Also, it is unclear whether respondents interpreted the question as implying money spent in addition to any current spending, or inclusive of. We have assumed that current spending is zero, and so the whole willingness to pay is consumer surplus.

Using the same estimate of household recycling at 4.8kg per week, this willingness to pay generates a consumer surplus value of $350 per tonne; in analysis we use the values derived from WTST, while noting that the high end of our range used in analysis is similar to that derived from WTP.

It is unclear whether respondents considered the WTP and WTST time as substitutes or as additive. We have assumed these are substitutes and therefore have not added the two together. This may underestimate total surplus.

Organic recycling

On average people are willing to pay $1.50 per household per week to dispose of their organic waste (if they were unable to compost themselves). Very few people pay to have their organic waste recycled currently, and we have assumed that average current spend is zero. So to derive a surplus requires that an estimate of actual time that would be spent is subtracted from the willingness to pay. We have no such estimates of actual time or actual spend that would be required.

In the absence of these data, we assume that the consumer surplus is the same as for PP&G waste.

Car tyre and oil recycling

On average, people are willing to pay $2.22 to ensure one car tyre is recycled and $2.10 for one oil change. Some people pay for these services already through the total cost of buying a new tyre and getting a lube and oil change. However we believe that it is reasonable to consider willingness to pay as additional to what people may currently spend, largely on account of the small monetary value of the WTP and people's lack of knowledge about what happens to their end-of-life tyres and used oil. It must be noted that these surpluses would be lower if respondents considered this as including any amount already spent.

With a surplus of $2.22 for each tyre, assuming that an average tyre weighs 8kg, the consumer surplus from recycling car tyres is $278 per tonne.

With a surplus of $2.10 for each oil change, we have assumed that 5 litres of oil are used in each change, and also that 1 litre of oil weighs 0.8kg. Thus the consumer surplus for car oil is $0.42 per litre, or $525 per tonne.

Have we misinterpreted avoided cost as consumer surplus?

It could be argued that people are willing to spend time and money recycling above what they are currently spending, not because there is some present consumer surplus, but because this allows them to avoid the costs of waste disposal.

Many people pay for their waste to be collected per volume, in the form of rubbish bags official labels or contracts with collection companies for rubbish bins. These people would be expected to be willing to pay up to the cost of waste disposal in order to get their waste recycled, as this is simply a cost-minimisation choice.

However, these benefits of avoided landfill disposal and collection costs have already been taken into account in analysis. To net these off the consumer surplus would be double counting.

In addition, we tested the extent to which respondents took account of their costs of disposal in suggesting a willingness to pay. We used tests for the difference of two means to ascertain whether the results for WTP and WTST differed by waste collection method. We found no significant difference between the willingness to spend time or to pay between any of the groups of people based on the way they pay for their rubbish collection. Any weak evidence from one question was not repeated for any other questions. It seems that respondents did not consider the savings on waste disposal when answering the WTP or WTST questions.