A Container Return System for New Zealand

Cost-benefit analysis update

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Glossary

BCR	Benefit-Cost Ratio
BAU	Business As Usual
CBA	Cost-Benefit Analysis
CDS	Container Deposit Scheme
CRCs	Community Recycling Centres
CRS	Container Return Scheme
GHG	Greenhouse gas
HDPE	High density polyethylene
KNZB	Keep New Zealand Beautiful
LPB	Liquid paperboard
MA	Managing Agency
MCF	Material Consolidation Facility
MRFs	Material Recovery Facilities
OTC	Over the Counter
PET	Polyethylene terephthalate
RF	Return Facility
RVM	Reverse Vending Machine
TLA	Territorial Local Authority
WG	Working Group

Executive summary

This report presents the findings of an update to economic cost-benefit analysis (CBA) of a container return scheme (CRS) in New Zealand.

The CBA relies on updated financial modelling from PwC finalised in January 2022. That is, we largely take as given the design features, options and operations of a CRS based on expert input.

Compared to a 'business as usual' situation of no CRS, a CRS would result in society being better off to the tune of $1,391 million, in present value terms. In that scenario, benefits exceed costs by 61 per cent. Such a 'business as usual' counterfactual necessarily assumes that the existing pattern and volume of recycling and other factors affecting willingness to recycle remain unchanged throughout the study period. This may seem unrealistic but is the most tractable approach given our lack of knowledge around the future, particularly over a 30-year period. To attempt to predict likely outcomes in that time effectively reflects 'the pretence of knowledge', which can lead to less useful and potentially incorrect results.

The central estimate of the largest categories of benefits (welfare gain from reduced litter and increased recycling) is the average of two willingness to pay studies representing the midpoint of the two studies' results. Using only the lower of these two estimates for both litter reduction and increased recycling would result in $100 million net benefit, and applying only the higher estimates results in $2,682 million net benefit. While acknowledging the large spread in estimated benefits and the well-rehearsed caveats around results using such estimating approaches, the studies represent the best available – though not perfect – information. We present the midpoint results with a range in brackets.

These results are largely robust to sensitivity testing.

Category	CRS estimates
Total benefits ($m, PV)	$3,667 ($2,376 to $4,958)
Total costs ($m, PV)	$2,276
Net benefits ($m, PV)	$1,391 ($100 to $2,682)
Benefit-cost ratio	1.61 (1.04 to 2.18)

Introduction and background

This report is an update of previous cost-benefit analysis (CBA) for a New Zealand container return scheme (CRS) finalised in February 2021. The update is required due to direction from the Government on the proposed design of a New Zealand CRS (for the purpose of public consultation), ahead of key decisions on whether to progress with a scheme for New Zealand.

CRSs have a range of objectives, meaning precise problem definition is elusive

Cost-benefit analysis is usually motivated by a problem statement. CRSs are designed to address several issues related to waste markets and consumer behaviour. A high-level problem statement relevant for this analysis is as follows:

A mismatch between private costs and social costs of disposal and recycling leads to excessive amounts of beverage containers being disposed into landfill or discarded as litter.

We acknowledge that the expression of the problem a CRS (as designed) could address is part of the wider policy development and consideration process, but we include a problem statement here for clarity and completeness.

This analysis follows previous work

In 2016, Auckland Council commissioned us to prepare a CBA of a proposed container deposit scheme (CDS). Data from Auckland Council were combined with specialist advice and extrapolated to the national situation. The CDS modelled was 'generic' in nature, with a range of assumptions applied for tractability reasons.

The 2016 CBA indicated that society would be better off from the introduction of a CDS, relative to the status quo of no CDS. Benefits exceeded costs by a factor of around three, meaning society was better off by $184 million in present value terms, across the 10-year study period.

Subsequently, in September 2019 funding was provided by the Waste Minimisation Fund to *Design a Container Return Scheme for New Zealand* in particular, and a Working Group (WG) was put together to advise on scheme design.

A CBA of the resulting scheme, referred to as a CRS, was part of the work programme of the WG. Relative to the previous work, the analysis extended the study period to 30 years, modelled two scenarios (i.e. a CRS with and without glass containers) and included additional effects (e.g. emissions and machine-based return facilities).

Compared to a 'business as usual' situation of no CRS, a CRS that includes glass containers would result in society being better off to the tune of $1,089 million, in present value terms. In that scenario, benefits exceed costs by 49 per cent. If glass containers were removed from the CRS design, society would be made better off from introducing a CRS by $68 million and benefits exceed costs by 6 per cent.

The results were largely robust to changes in the discount rate applied and the analysis time period. However, results were sensitive to the type of metric chosen to measure the litter. Using item count caused the benefit-cost ratio (BCR) to decrease to 0.92 and increase to 1.97 if weight was used rather than the average of weight, item count and volume reported in the central scenario to avoid bias of selecting one metric.

The CBA was peer reviewed by Sense Partners, with the results presented reflecting feedback given as part of that review. In addition, a commissioned review by NZIER and feedback received from a range of stakeholders were also incorporated into the analysis, where available evidence allowed.

A return to retail model with fresh milk excluded

This update to analysis incorporates changes to design decisions and updates to primary sales and kerbside recycling data. As in the previous version of analysis, the inputs from PwC financial modelling are used as the basis for the economic analysis.

While the primary categories of costs and benefits are unchanged, there are some important changes. Rather than reporting the difference between glass-in and glass-out options throughout the report, glass-out is addressed in sensitivity testing.

Fresh milk containers were previously included; they are now proposed to be excluded. This changes the volume of plastic containers included. Specifically, it excludes most HDPE beverage plastic from the CRS. Plastic was previously treated as a single mixed material type due to analysis limitations; it is now separated in PET and HDPE but, due to data availability, it is assumed all HDPE is not included in the scheme (in reality, immaterial volumes of HDPE may still be in scope).

The number and type of return depots is updated based on the proposal for a mixed return to retail model. However, actual system implementation decisions and therefore costs are still unknown, meaning adjustments to this aspect of the model are limited to adding manual over-the-counter facilities and adjusting the volume of containers allocated to the three return depot types. The majority of return depots and the container volume throughput is forecast to utilise Reverse Vending Machines (RVMs).

There are also significant changes to the capital costs for the Material Consolidation Facilities (MCFs), the forecast growth rates for container numbers and updated base year values.

Further investigation into the recycling of existing liquid paperboard (LPB) containers found that while it is collected in kerbside recycling by one or two councils, it is unlikely to be recycled. A small recovery volume was previously counted as business as usual (BAU) kerbside recycling. Given the materials were unlikely to have been recycled, updated recycling figures have not included LPB. The very small change in volume has a negligible impact on over all recycling estimates.

Previously, the value of avoided marine litter was monetised. Upon review, this impact is now discussed qualitatively. This change is not material to the result and is in part a response to previous peer review that illuminated issues with the calculation and the source.

Data are imperfect and participants' responses uncertain

While this iterative process has increased the certainty associated with the estimated costs and benefits of the CRS, there are a number of assumptions required due to data gaps and inherent uncertainty.

Recycling data largely relies on council-reported information and some industry sources. Considerable effort has been put into collating the data, and while it represents the best available information, there are a number of unknowns meaning assumptions are required. These assumptions reduce the accuracy of estimates.

Commercial volumes have been estimated and used to refine assumptions around unaccounted-for material flows. Modelling assumes no net change to commercial recycling costs as a result of the CRS.[1] Adjustments have been made for what is collected and what is rejected as contamination. The estimates for volumes diverted from kerbside refuse are based on 25 days of auditing of domestic kerbside rubbish and recycling at five locations around New Zealand in 2019 (Yates, 2020). Since this bin auditing, behaviour may have changed, and key assumptions such as conversion ratios from container numbers to tonnes and vice-versa likely reduce accuracy.

Public space refuse and recycling volumes are uncertain but, on examination, appear to be relatively small in terms of beverage container recovery.

The consumer response to price changes is assumed to follow the evidence reported in Australia with a one-off across the board 6.5 per cent reduction (Queensland Productivity Commission , 2020). This is a simplifying assumption used in the PwC (2021) financial modelling. In reality there are numerous beverage types, sizes and product bundles that will all likely result in different price impacts and consumer demand responses. It is also uncertain if the scheme costs will be fully passed on to consumers or partially absorbed by producers.

[1] We assume commercial contracts will adjust in a manner that results in no net change in costs of recycling collection for businesses even though volumes may increase.

What we modelled

We have modelled a return to retail CRS model with fresh milk excluded. The specific details of return facilities – especially Reverse Vending Machine (RVM) models and location – are to be decided by retailers, so we have avoided speculation on opportunity and space costs. Due to commercial sensitivity, we use averages of available international examples for estimates of RVM costs.

Collection model

We model the capital and operating costs of three components of the CRS:

- Managing Agency (MA) oversees the operation and administration of the scheme.
- Material Consolidation Facility (MCF) collects, aggregates and bales returned containers for sale and processing.
- Return Facilities (RF) are locations for consumers to return containers for deposit refunds.

Costs for the MA and MCFs were provided by the 2021 PwC financial model, which includes updated data on volumes and changes to forecasting assumptions used previously. In the absence of information on the costs of the RFs, which we recognise would be available during the implementation (procurement) stage of a CRS, we used international evidence. The RFs are modelled as a mix of RVMs, Over the Counter (OTC) and automated depots that have differing cost structures and capacity. The 2020 WG guidance was for a lease model to operate the RVMs. Given data and confidentiality constraints, we continue with a lease cost rather than capital cost approach.

Scheme fees

The CRS fee is applied to all beverage containers, paid by the beverage producers and assumed to be fully passed on to retailers and ultimately consumers. The only relevant aspect for the CBA is the demand response to the price increase, which is modelled as a one-off 6.5 per cent reduction in beverage sales in year 1 of the scheme. Refer to PwC's (2021) financial model for details.

Ideally, for an economic CBA, we would use estimates of the price elasticity of demand for different beverages to model the reduction in consumption as a result of a price rise due to the CRS. As indicated in the earlier CBA iterations, there is very little data in New Zealand on the relevant elasticities.

In addition, the bundling options available for beverages (particularly alcohol) make it extremely difficult to determine the price impact and consequently the consumption reduction. Moreover, it is not a classical increase in price (e.g. from a tax), as consumers have the possibility of recouping most of the additional payment (although that is not costless). Thus, the somewhat 'blunt' and possibly overstated consumption reduction explained above is used in this analysis.

Material flow changes

As a result of the CRS, beverage containers are diverted from kerbside refuse and recycling collections, and the quantity of beverage containers that become litter is reduced.

Key inputs to determine BAU and CRS material volumes and flows were provided by PwC 2021 and the 2020 WG:

- Updated GS1 container sales data by beverage type and container material are used to establish consumption.
- WasteMINZ and Territorial Local Authority (TLA) data on the beverage container flows by material type in kerbside refuse and recycling collections across the country.
- Previously container consumption and disposal were modelled to grow at 2.03 per cent annually after the initial drop of 6.5 per cent in consumption when the CRS is introduced. PwC's (2021) updated analysis used the population growth rate for the growth in beverage container sales. We have followed this as it has implications for the capital costs for MCFs. The average population growth rate used over the core 30-year analysis period is 0.7 per cent.

The updated financial modelling assumes an initial total return rate of 75.5 per cent, which is 90 per cent of the maximum return rate (83.9 per cent), and that it takes three years to reach the maximum return rate (steady state achieved in year 4). The financial model return rate is used as the household participation rate. This means in year 1, 75.5 per cent of households will divert beverage containers from kerbside refuse and recycling into the CRS, and by year 4, 83.9 per cent of household beverage containers are diverted from kerbside collections, and this rate continues for the 30-year modelling period.[2]

Table 1: Change in eligible containers in kerbside recycling and refuse during implementation (tonnes)

Category	Year 1 (75.5% diversion)				Year 4 (83.9% diversion)			
	BAU		CRS		BAU		CRS	
Kerbside	Recycling	Refuse	Recycling	Refuse	Recycling	Refuse	Recycling	Refuse
PET	4,521	5,213	1,015	1,193	4,644	5,355	801	806
LPB	-	2,719	-	622	-	2,793	-	420
Metal (aluminium)	3,809	1,683	864	385	3,913	1,729	682	260
Glass	110,566	12,374	25,308	2,832	113,578	12,712	19,989	1,912

[2] Note the actual change in volume is greater due to reduce demand (6.5 per cent) from the CRS price being passed onto consumers.

HDPE	2,418	2,185	2,418	2,185	2,484	2,245	2,484	2,245
Total	**121,313**	**24,175**	**29,605**	**7,219**	**124,618**	**24,834**	**23,957**	**5,643**

Source: PwC 2021 financial model, Sapere analysis.
Note these figures represent the tonnes of eligible containers in the kerbside refuse and recycling streams.

Litter volumes are modelled to reduce by 61 per cent once the CRS is fully implemented. 60 per cent of this reduction happens in year 1 and 100 per cent by year 4. Establishing a baseline for the level of litter is challenging. Assuming that half the unaccounted-for container volumes become litter aligns roughly with the Keep New Zealand Beautiful (KNZB) national litter audit that reports a total of 190,000 tonnes litter was collected in 2016. The 2019 survey finds 36 per cent of litter by weight is beverage containers, which equates to 69,000 tonnes. If the average of metrics (item, weight and volume) is used, this results in around 45,000 tonnes of beverage container litter. Beverage litter is modelled to reduce by about 26,000 tonnes in year 1 and around 42,000 tonnes once the full impact is achieved, as seen in Table 2. The actual tonnes of litter have little impact on the benefits and costs modelled, as the benefit calculation for litter reduction is based on the percentage reduction in litter expected.

Table 2: Change in litter volumes (tonnes)

Category	Year 1 (60% impact)		Year 4 (100% impact)	
	BAU	CRS	BAU	CRS
HDPE	3,531	3,531	3,627	3,627
PET	6,401	3,785	6,575	2,382
LPB	2,028	1,169	2,057	736
Metal (aluminium)	4,627	2,731	4,753	1,719
Glass	50,567	29,905	51,944	18,820
Total	**67,154**	**41,121**	**68,958**	**27,284**

Source: Sapere analysis

Return rates modelled through assumed household participation rates

We did not assume that the CRS will achieve a set rate of material recovery, as the details of the system implemented and how consumers react involve a high degree of uncertainty. Data limitations and gaps, particularly around commercial flows, mean we did not have visibility over what the assumed diversion would be displacing and thus could not calculate the net impact.

We applied assumptions to the areas where there was the best data, household kerbside collections and litter reduction. We use household participation rates to assume the volume of material that is diverted from kerbside refuse and recycling schemes into the CRS.[3] We feel this more conservative approach is appropriate given the inherent uncertainty and nature of supporting data available.

Table 3: Recovery of material flows CRS and BAU (tonnes)

Category	Year 1 BAU	Year 1 CRS	Year 4 BAU	Year 4 CRS
Total consumption	319,889	302,602	328,604	308,703
Total kerbside recycling	121,313	29,605	124,618	20,839
CRS recycling transferred from kerbside recycling	-	83,866	-	95,723
CRS recycling transferred from kerbside refuse	-	15,527	-	17,722
CRS from Kerbside contamination		7,354		7,554
CRS recycling from litter	-	21,833	-	37,362
Total recycling with CRS	-	158,184	-	179,200
Commercial recycling[4]	22,901		23,542	
Recovery rate	**45%**	**60%**	**45%**	**66%**

Source: Sapere analysis, PwC 2020 financial model

The table above captures only the flows where we have sufficient data to model changes brought about by the CRS. The table is restricted to the diversion of eligible containers from kerbside collections and a reduction in litter.

[3] As stated earlier, the household participation rates are aligned with the financial modelling return rates.

[4] While not included in modelling it is likely commercial recycling rates will increase with costs to business unchanged.

Relevant costs and benefits

The categories of costs and benefits included in this analysis are summarised in Table 4.

Employment effects are not included, but are a qualitative feature of a CRS

In common with other proposals of this nature, claims are often made that employment opportunities arise from a CRS and that these opportunities are a benefit that should be included in any economic CBA. In general, economic CBA does not directly or explicitly include employment effects. This is the position that was taken in the previous CBA.

The opportunity cost of labour employed (i.e. the going wage rate) is implicitly included as part of the various cost elements, while any beneficial effect that arises from the deployment of labour to produce goods or services would be captured in terms of the outputs of that labour process (e.g. in the scale of additional recycling, or reduced litter).

The rationale behind excluding employment effects is that labour resources used to undertake activities associated with a CRS would (or could) have been deployed elsewhere in the economy, and it is therefore a resource transfer rather than resource creation. However, where there is unemployment in the relevant catchment or for the relevant skill area, it is possible that the opportunity cost of labour employed could be low (perhaps even zero) (Treasury, 2021, p. 17).

In such cases the impact of employment could be viewed as positive (i.e. the output produced comes at very low or no cost). There may also be fiscal benefits if the labour that is to be used was previously receiving transfer payments from the government but would no longer do so following a CRS.

Lack of available data and the transfer nature of employment effects (i.e. labour deployed as part of a CRS would likely have been deployed elsewhere in the economy) means we do not include employment effects in the analysis.

We note, however, that the benefits associated with employment may be broader than just the market wage, with such "externalities" thought to include better civic engagement, enhanced social interactions and overall gains in self-esteem/well-being.

Measuring consumer welfare with willingness to pay

The major non-market benefit category relates to consumer welfare (see Table 4). In particular, people may perceive and value the aesthetics of cleaner public places due to less (beverage container) litter now and into the future (i.e. "bequest" benefits for future generations from less visible litter and litter going to landfill).

Two studies that sought to quantify/monetise such amenity benefits have been frequently cited in analysis of CRS[5] and other waste management projects.[6] PwC (2010) is an Australian study and Wardman et al., (2011) a similar United Kingdom based study. The PwC (2010) study also quantifies the value of increased recycling, as does the New Zealand based Covec (2007) study on willingness to pay for increased recycling.

Willingness-to-pay surveys have been accused of producing over-stated benefits, as respondents may not fully understand the context of the question. Perhaps more importantly, respondents can claim values that are greater than what they would actually pay as they don't believe there is a strong possibility that they will be faced with having to pay.

In the context of litter reduction, a particular question is whether the willingness to pay is predicated on the mechanism used to bring about the change in question. In particular, is adequate consideration given to the cost-effectiveness of particular options to reduce litter? Covec (2016) suggests that amenity values should only be included in analysis if a CRS is the most cost-effective policy to reduce litter and increase public space amenity and that further work should be done on optimal litter reduction measures.

While we agree further research would be helpful, we also acknowledge that analyses of this type often take place in an information-poor environment, and judgment is required. In other words, it is very rare for a CBA to take place with perfect information or complete certainty. Reliance on the best available evidence will always be required, and we believe that this is the case here. In addition, the objective of a CBA is to determine the extent to which society is made better off (if at all) as a result of a policy proposal, rather than to necessarily determine the least cost method of achieving a particular goal.

A further question that has been raised in relation to the type of direct consumer benefits under study here is whether they are additional to the other benefits. Covec (2007) questioned whether there is a benefit that households are receiving that is not accounted for elsewhere. Their view was that there is, and that including the consumer surplus (the difference between their willingness to pay and current costs of litter reduction) can be added to other avoided cost-related benefits.

We consider increased recycling benefits to be additional to those in respect of litter reduction, as we interpret litter reduction as relating to visual amenity (i.e. the presence of litter), while recycling is what happens to relevant litter once it is cleared (i.e. the appropriate disposal of beverage containers).

[5] See NSW EPA, (2017); Government of Western Australia (b), (2018); ACT Government, (2018).

[6] Such as Perry, Varua, & Hewitson, (2018)

Table 4: Overview of costs and benefits

	Description	Calculation used	Source
Costs			
Household participation	Costs incurred by households for activity related to the CRS	Time required multiplied by time cost multiplied by proportion of participating households	NZTA Economic Evaluation Manual, author's estimates
Infrastructure-capital	Asset costs for processing and collecting containers for MCFs	Estimated market cost of assets	SDWG, PwC (2020), Author's estimates
Infrastructure-operating	Transport, administration, handling and processing/staff costs for MCFs, collection facilities and Managing Agency	Cost per tonne for transport and handling Annual estimated labour and other costs	PwC (2020), Auckland Council
Labelling	Costs to display information on containers, potentially including bar codes and value of refund	One-off cost based on product lines and daily cost for four days' work by design company	Hogg et al (2015), Eunomia
Exporting cost	Costs associated with sending additional volumes of recyclate matter offshore	Price per tonne, by recyclate matter	PwC (2020)

	Description	Calculation used	Source
Benefits			
Welfare gain from additional recycling	The value households place on additional recycling as a result of a CRS	Willingness to pay per household multiplied by the net change in volumes for the relevant number of households. Updated to today's value and averaged across two sources used.	PwC (2010), Covec (2007)
Welfare gain from less litter	The value households place on the reduction in litter recycling as a result of a CRS	Willingness to pay per household multiplied by the net change in volumes for the relevant number of households. Updated to today's value and averaged across two sources used.	PwC (2010), Wardman et al, (2011)
Lower landfill costs	Avoided costs of landfill due to tonnes diverted from kerbside refuse	Diverted volume multiplied by cost per tonne of landfill	PwC (2020)
Value of material collected	Additional value due to better quality of material	Dollar value per tonne for relevant material type multiplied by respective volume	PwC (2020)

	Description	Calculation used	Source
Reduced litter clean-up costs-market-based	Lower costs of litter clean-up due to reduced volume of litter	Dollar cost per person multiplied by relevant litter reduction	Auckland Council, Author's calculations
Reduced litter clean-up costs-non-market-based	Avoided damage from marine litter and notional value of volunteers	Qualitative.	Beaumont et al (2019), NZTA Economic Evaluation Manual, Author's calculations
Reduced contamination	The lower level of contamination in landfills as a result of better quality/less-contaminating material ending up in landfills	Reduction in tonnage multiplied by landfill cost	PwC (2020), Author's estimates
Emissions	Impact on carbon footprint as a result of CRS. Largest impact stems from replacing virgin material.	Net total of additional emissions from transporting material and reduced emissions from replacing virgin use and landfill emissions (due to paperboard)	NZTA Economic Evaluation Manual, UK Government (for emissions factors)
Lower collection costs	Savings from reduced burden of kerbside collection	Reduction in volume of kerbside refuse and recycling multiplied by cost saving per tonne	PwC (2020), Covec (2016)

* denotes categories not included in previous work

Estimated costs and benefits

This section presents the (quantified) estimates of the costs and benefits of the CRS, as proposed. The estimates are based on the core assumptions contained in Table 5. We highlight that, where value ranges are presented, we use the midpoint for modelling purposes.

Table 5: Core assumptions

Relevant factor	Value	Source
Discount rate	5%	Treasury (2021)
Study period	30 years	Author's estimate
Phase-in period to steady state	3 years	PwC (2021)
Average annual household and consumption growth	0.69%	Statistics New Zealand, PwC (2021)
Maximum household participation	83.9%	PwC (2021), estimate of return rate used as proxy for participation

Total costs of $2,276 million

Modelling estimates the CRS to cost almost $2.3 billion over 30 years, with household participation costs the largest single category of costs at $751 million. Combined operating costs are almost $1.5 billion with Return Facilities ($628 million), Material Consolidation Facilities ($429 million) and the Managing Agency ($409 million) the highest components.

Table 6: Summary of costs (30 year Present Value)

Cost categories	Value $ millions
Managing Agency	409
MCF capital costs	26
MCF operating costs	429
Return facility costs	628
Participation costs	751
Labelling costs	11
Exporting cost	23
Total costs	**2,276**

Material Consolidation Facilities capital costs of $26 million

Capital costs relate to the assets required for the MCFs only. Long-term assets have an asset life of 35 years, and terminal values[7] (of $2.7 million) are netted off capital costs at year 30. Short-term assets are replaced every four years, so costs reappear every four years (see Table 7).

[7] Terminal value refers to the estimated useful life of assets and therefore, when assets have an expected life that exceeds the time period of the analysis some residual value remains, which needs to be accounted for in the analysis. In this case, the value of the estimated five remaining years of functional life of the assets are removed from the costs.

Table 7: Capital costs for MCF (PV, $m)

Category	Cost	Asset life
Long term assets (balers, conveyors and silos)	$18.6	35 years
Short term assets (conveyor belts)	$0.2	4 years
Land	$3.6	1.9ha at $186m^2
Cages	$4.4	35 years

Source: PwC (2021) Note the model uses an escalator and land costs have been updated to reflect recent value changes

Operating costs of $1,466 million

This category of costs is made up of operating expenses for the MA, MCFs and RFs.

Managing Agency costs total $409 million

Table 8 outlines the MA operating costs for the initial implementation phase and the 'steady state' or ongoing yearly costs.

Table 8: Managing agency fixed costs (PV, 2021 $m)

Year	Zero	One	Ongoing
Admin and support services	-	$11.3	$9.1
Professional services	$9.6	$3.9	$2.4
Marketing and communication	-	$5.7	$4.5
Employee benefits	$0.3	$3.8	$3.8
Other expenses	$1.7	$6.9	$6.9
Office lease	-	$0.2	$0.2

Source: PwC 2021 financial model

Material Consolidation Facilities costs total $429 million

The WG (and previous work) signalled an intention to make use of existing facilities such as Community Recycling Centres (CRCs) and existing return points for recycling and existing MRFs that could be converted, expanded or contracted for the required services.[8]

Nevertheless, there are still sizeable operating costs, reflecting the incremental volume of material that such facilities would face. There are transport and processing costs, which are based on cost per tonne multiplied by tonnage, as well as staff and utilities costs. Glass crushing costs are also included as we understand that local bottle-to-bottle processing is at capacity and any additional glass returned due to the CRS would need to be crushed in the absence of any other regulatory or system changes.

Table 9 shows that total transport and processing costs are estimated to be $331 million. The glass cost per tonne figures are at the high end of ranges considered, possibly overstating true costs of glass transport and processing.

Table 9: Transport and processing costs

Category	Cost per tonne	Steady-state cost (PV, $m)	30-year cost (PV, $m)
Transport (plastic, metal, LPB)	$171	$3	$57
Transport glass	$112	$12	$230
Glass crushing	$90	$2	$43

Source: PwC Financial modelling final report July 2020 and PwC 2021, Sapere analysis

Staff and utilities costs are estimated at $98 million, based on financial modelling by PwC that uses escalators to increase costs with material throughput.

Table 10: Variable costs per MCF (PV, $m)

Category	Initial costs	30 year cost (PV, $m)
Staff costs	$3.9	$84
Utilities costs	$0.8	$14

Source: PwC Financial model 2021

[8] Whether this is practical remains to be seen and is a matter for the future managing agency to determine, alongside other considerations such as fraud risk management

Return facilities costs total $628 million

The costs included in this category are population-based, with one facility for every 6,400 people. Based on a 2019 population of 4.9 million, 816 return facilities (103 over the counter, 51 automated depots and 662 RVM locations) are included in year 1 of the modelling and increase in a constant ratio with population growth. As indicated earlier, RVMs make up 85 per cent of facilities and the remaining 15 per cent are OTC and automated depot return facilities.

The model has the costs of leasing and maintaining the RVMs fixed but the number of RVMs growing with population, so the cost per container drops as the CRS is implemented then stays constant. In year 1, RVMs cost 4.4 cents per container, while by year 4, when the system is fully implemented, the cost per container is 3.6 cents. The assumption for OTC and automated depot return facilities is a constant 3.0 cents per container.

RVMs are usually considered more efficient for the system. For example, they can reduce collection costs through compacting containers and automatically verify units, further reducing administrative costs (Edwards, Grushack, Elliot, Kelly, & Card, 2019).

The costs for RFs have been estimated by reference to international evidence, applied to New Zealand with relatively little adaptation. Thus, there is more of a question about the validity of these estimates than is the case for others. We have sought to calibrate the model estimates with CRS financials and material volumes as a check, but doubt around the precision of these estimates remains.

Reverse vending machines costs total $549 million, based on the recommended lease model

The space, capital and operating expenses all differ across potentially suitable models. It is likely that a range of models would be used depending on the volumes expected at an RF.

A lease model is proposed for the RVM return facilities. While there are many iterations that could eventuate, we make simplifying assumptions and rely on international experience to estimate the costs involved.

We estimate, based on publicly available information, lease costs would total $31 million per year. The inputs into that cost estimate follow.

Model specifications important for capital, space and participation costs

The recently launched Tomra R1 model enables over 100 empty beverage containers to be inserted into the machine at one time, meaning the household participation costs could be drastically reduced when compared to a single-feed machine.

The standard T-90 Tomra RVM has two chambers, meaning two machines would be required per location for a CRS including glass, plastic, LPB and metal cans.

Capital cost estimates

In 2015, Zero Waste Scotland estimated that the upfront cost of an RVM would cost £30,000, development of the business case and scheme design resulted in a forecast of approximately 3,000 RVMs required, with upfront capital costs of approximately £60 million (Scottish Government, 2019).

A report prepared for British Glass indicates Tomra RVM model costs range from £19,000 to £25,000 with glass and £17,100 to £22,500 without glass. A lease for a standard model is estimated at £7,190 per year. Assumed functioning life of models ranges from five to seven years (Simpson, 2019).

Cost per machine

We convert to NZD at an exchange of 1.97[9] and inflate to 2021 dollar terms for a lease cost of $14,762 per RVM per year.

2200 RVMs required

The average density of RVMs in Europe is around 1 per 1,900 people. This is deemed appropriate for Scotland based on similar population densities (Hogg, et al., 2015). Using the assumption that 85 per cent of return facilities will be RVMs and serve 85 per cent of the population results in an assumption of almost 2,300 RVMs required in year 1 and 2,400 in year 4. This equates to about four RVMs per return facility. We acknowledge the design of the Scottish system has some key differences to the proposed design. The mandatory Scottish model means there is a much larger number of return points in the Scottish model than is proposed for New Zealand. It is therefore quite possible that a lower number of RVMs will be required per return facility with a minimum of two RVMs likely (one for glass and another for plastic, metal and LPB). As we have not made any allowance for space and operating costs of RVMs, we consider the potential over-estimate in the number of RVMs required to best approximate actual costs. Modelling suggests allowing for around 1.5 cents per container of operating costs and reducing the number of RVMs to two per location results in similar costs.

Without knowledge of the specification of the machines it is hard to determine if these assumptions are appropriate for the volumes of material modelled.

Over the counter return facilities ($26 million) and automated depot facilities ($52 million) cost $79 million

For OTC and automated depot return facilities, we use estimates from Australia, the United Kingdom and Canada for an average cost of 2.7 cents per container, which after adjusting for income differences and inflation give an average of 3.0 cents per container (see Table 11). The Ontario and Scottish models are designed to encourage more adoption of RVMs as this reduces the overall cost of the system, whereas the Australian estimate accounts for increased cost in remote locations.

[9] Three-year average exchange rate available at https://www.ofx.com/en-ca/forex-news/historical-exchange-rates/yearly-average-rates/

Table 11: Manual return depot costs cents per container

Cost Element	Ontario (2019)	Scotland (2019)	Australia (2013)	Average
Original	0.73	1.5	6	2.3
Updated	0.80	2.8	5.3	3.0

Source: (Edwards, Grushack, Elliot, Kelly, & Card, 2019; Scottish Government, 2019; Marsden Jacobs, 2013)

Labelling costs of $11.4 million

An allowance for one-off changes to beverage container labels is based on international examples. Industry will have a greater understanding of how these costs translate to the local setting. It seems, with appropriate consultation and timing of the introduction, these costs could be minimised or largely incorporated into other design updates and reviews.

Exporting costs of $21.5 million

The total additional tonnes of recovered material that is exported for processing is multiplied by costs provided in PwC financial model. LPB is exported at a cost of $190 per tonne and metal at $100 per tonne (PwC, 2022).

Participation costs total $751 million

Beverage containers must be sorted, stored, and transported to return facilities. Thus, there are two elements to household participation costs: the additional time needed to sort and return/redeem the containers and the transportation costs to get to the return facility. This estimates the increased cost to households to claim the deposit refund.

Any change in costs to households/consumers from the scheme passed onto consumers as price increase are highly uncertain. At 100% pass through of cost to consumers, financial modelling assumes a 23 cents per container cost from the scheme whereas the economic cost is estimated as the cost of the managing agency, return facilities and material consolidation facilities.

Household time cost of $370 million

As a result of the CRS, households are likely to spend additional to time sort, store and redeem containers. We assume that such trips will often be combined with other trips, such as weekly grocery shopping.

As indicated above, containers can be returned either at a depot, or by RVM. For this analysis, we assume 85 per cent of containers will be returned through RVMs, 10 per cent at automated return depots and 5 per cent at OTC (manual) depots.

Table 12: Household participation time variables (seconds per week) for RVMs

Weekly components	Low	High	Midpoint
Additional sorting and storing	30	60	45
Walk time	30	60	45
Wait time	10	30	20
Total	70	150	110
Seconds per container	3	5	4

Given the number of containers assumed to be redeemed per household, the figures above translate into households spending just **under one and a half hours per year** participating via RVMs once the CRS is fully up and running, made up of around 0.66 hours per year putting containers into RVMs and 0.79 hours in additional sorting, storing, walking and wait time per year.

In the case of OTC (manual) and automated depot return facilities, we assume monthly to quarterly frequency (i.e. eight return trips per household per year). These trips are estimated to take five to 10 minutes per trip. Based on these figures and a test of likely container number thresholds to generate a trip, our best estimate of the time taken by households to use OTC and automated collection depots **is one hour per household per year**.

These time estimates are comparable to findings from overseas studies:

- Container deposit redemption time is 1.6 minutes for RVM and 10 minutes for other refund points (Government of Western Australia (a), 2018).
- RVM is equivalent to 1.7 minutes. Return facility, five minutes per transaction (PwC & WSC, 2011).

We used a household value of time of $10.63 per hour. This value is the same category of time cost used in the previous CBA, adjusted upwards (from $6.90 per hour) by the update factor contained in the New Zealand Transport Agency Economic Evaluation Manual (EEM). Reflecting the information we have to hand and the assumption around CRS-dedicated trips being in the minority, the monetary value chosen is the lowest of those contained in the NZTA EEM. In effect, the opportunity cost of households' time is minimal, as sorting would occur at home and the redemption trip is, by and large, already being undertaken and hence does not crowd-out otherwise valuable time.

The present value of total time costs for household participation is estimated at $370 million.

Transport cost $380 million

We combine vehicle operating costs (calculated by multiplying estimated additional kilometres travelled and cost per km given by Inland Revenue of $0.79) and the extra time travelling, a function of distance and speed multiplied by the NZTA EEM time costs of $10.63 per hour. Table 13 summarises the transport-related costs.

Underlying assumptions are set out further below.

Table 13: Breakdown of household transport costs (PV, $m)

Component	Value
Vehicle operating costs	$268.6
Time in car	$111.9

We assume that 10 per cent of trips to both RVMs and automated depots and OTC (manual) return facilities are new trips, on the basis that:

- the origin of shopping trips is not always the household, e.g. people may shop on the way home from work
- households are not likely to make a trip for the sole purpose of returning containers unless they have a significant quantity (PwC & WSC, 2011).

Table 14: Distance and frequency assumptions for participation cost estimation

Depot type	Share of returns	Distance (km)	Average speed (km/h)	Time per trip (minutes)	New trips per year	Minutes per year
RVM	80%	5	30	10	2.6	26
Manual	5%	20	50	24	0.8	19
Automated	15%	20	50	24	0.8	19

Total benefits $3,667 million over 30 years

Total benefits are estimated to be over $3.6 billion over 30 years. The largest category is the welfare gain from a reduction in litter with increased recycling also resulting in significant benefit.

Table 15: Benefits summary (PV 30 year total)

Benefit category	Value $ millions
Welfare gain from increased recycling	913
Welfare gain from reduced litter	2,348
Value of additional material recovery	101
Litter clean-up costs	69
Litter volunteers	4
Avoided landfill costs	35
Kerbside collection savings	113
Reduced contamination of recycling	27
Emissions	56
Total benefits	**3,667**

Welfare gain from increased recycling is $912 million

The welfare gain to households is proxied by their willingness to pay for additional recycling. This willingness to pay is expressed in terms of weight, which naturally places greater emphasis on glass containers. We acknowledge that use of a weight measure might mean that some estimates could be mis-stated, but we were unable to source any evidence on which to base willingness-to-pay figures for alternative recycling measures, such as item counts.

Rather than rely on a single measure, we have used two separate studies and derived the estimated benefits using a simple average. The average willingness-to-pay value used in the modelling at year 4 is $35.67 per household per year for increased recycling.

As indicated above, these studies reflect the best available – rather than ideal – information. Both studies are somewhat dated, and one reflects Australian household values, which can only be translated to New Zealand equivalents imperfectly. Further, the method used to produce values of willingness to pay is known to be subject to questions. Absent a more up-to-date and comprehensively designed study, these values remain the only plausible representation of household values. Setting aside the values due to questions on the actual size of the estimated effects would, in our view, result in a less complete picture of relevant costs and benefits.

The first method produces benefits of $1,518 million

The first method, from PwC (2010), estimates households are willing to pay, on average, $2.77 per year for every 1 per cent increase in the weight of waste packaging recycled (PwC, 2010). This is adjusted for income differences and inflation to $2.72 per percentage point increase. The CRS is modelled to increase the indirect recycling rate by 19 per cent once fully implemented, which translates to households being willing to pay $60 per year for the increase in recycling from indirect sources such as litter and kerbside refuse.[10]

The second method results in benefits of $308 million

Covec (2007) used a survey to find that people were willing to pay $1.68/week to recycle paper, plastic and glass, which implied a surplus of $350/tonne (based on 4.8 kg per week). Using the EEM cost update factors to adjust the $6.90 figure used for the value of time to $10.63 per hour resulted in a value per tonne of $373, compared to $242 per tonne used in the previous analysis. This led to a willingness-to-pay figure of $11 per household per year and total benefits of $307 million. This method would seem to understate value as it does not include aluminium cans, which would likely be part of the CRS. Once fully implemented, the modelling conducted (which only considers transfers from kerbside refuse and reduction in litter and recycling contamination) results in the CRS increasing recycling of beverage containers by around 55,000 tonnes per year.

Welfare gain from reduced litter is around $2,348 million

The approach to calculating the welfare gain is very similar to that used for estimates of the benefits of additional recycling, utilising willingness-to-pay data and averaging across two separate sources. Like the benefit estimates associated with additional recycling, litter benefits are weight-based. Further, the same caveats identified above in relation to additional recycling apply.

The first step was to estimate the proportion of litter explained by beverage containers. We used the 2019 Keep New Zealand Beautiful (KNZB) national litter audit and then calibrated assumptions on proportion of consumption that becomes litter with the 190,000 tonnes litter that was collected in 2016.

[10] This only accounts for increased recycling from litter reduction, transfers from kerbside refuse to the CRS and a reduction in recycling contamination.

Table 16 indicates that the percentage of litter that beverage containers account for is 23.6 per cent. This figure was derived using an average of all the metrics available in the KNZB litter audit including weight, volume and item. [11]

Overseas evidence suggests that litter reduction due to CRS implementation produces an average of 61 per cent less container waste, from a range of 84 per cent to 35 per cent (Bottlebill.org; NSW EPA, 2019; Boomerang Alliance, 2020; West, Angel, Kelman, & Lazarro, 2013). The average litter reduction based on composition and overseas evidence is 14.5 per cent for all containers.

Table 16: Litter reduction due to CRS

Litter reduction	Current beverage container litter	Average (61%)	High (84%)	Low (35%)
Percentage litter from beverage containers	23.6%	14.5%	19.8%	8.3%
Total litter reduction (stadium effect)		47%	64%	30%

Source: KNZB litter audit 2019, Sapere analysis

While the average figures are slightly above estimated litter reduction from beverage containers in the 2016 CBA, they may still be understated given the possibility outlined in some of the overseas studies cited above that a CRS would reduce total litter rather than just beverage container litter, possibly due to behavioural biases such as the stadium effect, which we explain further below. We have not included such effects in the core modelling but investigate the impact in sensitivity testing.

Benefits of $1,724 million estimated in one study

An Australian study finds households are willing to pay, on average, $4.15 per 1 per cent point reduction in litter, or $41.50 per annum for a 10 per cent reduction in litter and $83.00 for a 20 per cent reduction (PwC, 2010). Equating to New Zealand dollar terms and adjusting for income differences and inflation results in a value of $4.08. A 14.5 per cent reduction in litter would result in households being willing to pay $59 per year.

This study has been used in the economic analysis of NSW and Western Australia CDS schemes.

[11] Lids and caps are included as beverage container related litter. While the lids and caps are not directly part of the refund, given the evidence that CRS can reduce total litter supports their inclusion in the litter calculations.

Benefits of $2,972 million estimated in another study

A University of Leeds study for DEFRA found that people were willing to spend £3.95 per month on council tax for a 1 point improvement on a 10 point litter scale. On this basis, it is estimated that each household would be willing to spend an additional £47.40 on council tax per year to achieve a 1 point reduction of litter (Wardman, Bristow, Shires, Chintakayala, & Nellthorp, 2011).

Equating the £47.40 to New Zealand dollar terms, adjusting for income differences and inflation, results in a value of $70.38. Translating that effective 10 per cent reduction in litter to the average of 14.5 per cent reduction in New Zealand results in an estimated willingness-to-pay of $102 per household per year for the reduction.

Using benefit transfer, Marsden Jacob Associates estimate the willingness to pay, using recalibrated study results from the United Kingdom, to be between $67.78 and $81.37 per person per year in an Australian context.

Additional value from material recycled is $101 million

The extra CRS material collected for recycling would have an additional market value. In addition, the value of existing collected materials would increase due to reduced cross-contamination (i.e. a CRS produces cleaner material than existing systems).

Table 17 contains the components used in the calculation of benefits. At the 'steady state' of the CRS, about $7 million a year in benefits would accrue that otherwise wouldn't.

Glass is not included in calculation as there are costs to crush regardless. Current bottle to bottle recycling is at capacity, so increased material is considered a cost to crush rather than a benefit through sales of revenue-generating material. Investment in increased capacity could increase the value of collected glass. HDPE is milk container material so is also not included.

Table 17: Value of CRS materials recovered, PV

Revenue per tonne	$/tonne	Tonnes CRS steady-state	Value, $m per year
HDPE	$650	-	-
PET	$200	7,788	$1.6
LPB	$10	3,007	$0.03
Metal (aluminium)	$1,250	4,189	$5.2
Glass	-	-	-
Total			**$6.9**

Source: PwC financial model ($/tonne from PwC) Tonnes calculated by Sapere analysis

Reduced contamination of kerbside recycling $27 million

Broken glass is a common contaminant. With the 81 per cent reduction in kerbside volumes, a plausible assumption is that the CRS reduces contamination rates at MRFs by half. Current contamination rates are reported to be around 12 per cent. The reduction in volume of contamination is multiplied by a conservative estimate of the landfill cost, $129 per tonne.

The volume of beverage containers that were lost in contamination is transferred to the CRS. This is equal to about 7,500 tonnes per year in the steady state.

Kerbside collection costs are $113 million lower

The CRS reduces collection costs by removing cumbersome, low-value glass and higher-value but still bulky plastic bottles from the waste stream, allowing for better productivity and efficiency in collection.[12] The saving of $60 per tonne estimated by (Covec (2016) and used in the previous CBA is multiplied by the difference in volume from kerbside refuse and recycling with and without a CRS.

Table 18: Reduction in kerbside collection costs

Category	Tonnes CRS steady-state	Savings $m per year
Change in kerbside refuse	18,613	$1.1
Change in kerbside recycling	100,662	$6.1
Total change from CRS	**119,275**	**$7.2**

Source: Sapere analysis

Avoided landfill costs are $35 million

This is a simple calculation where tonnes of kerbside refuse diverted from landfill are multiplied by the $129 tonne landfill cost (see Table 19).

Table 19: Avoided landfill costs

Category	Tonnes CRS steady-state	Saving $m per year
Kerbside refuse diverted glass in	17,145	$1.4

Source: Sapere analysis, PwC financial model

[12] Councils could also see benefits from the unclaimed deposit value in the bins, but as this considered a "transfer" so is not considered an economic benefit.

Reduced litter clean-up costs are $69 million

Estimated litter clean-up costs in Auckland are in the order of $11 million per annum, which means average annual litter clean-up costs per person of $6.95, which is scaled to the national population.

Volunteer time savings are $4 million

This benefit is estimated by updating the value in the 2016 CBA for the new proportional reduction in litter (14.5 per cent), translating to hours spent by volunteers and multiplying by the updated NZTA EEM time costs of $10.63 per hour.

Reduced emissions result in benefit of $56 million

Greenhouse gas (GHG) reductions arise from the increase in recycling as a result of the CRS and the reduced volumes going to landfill. This is offset by the increased emissions from transporting additional material to recycling destinations. Due to lack of detailed data we have used a coarse approach relying on the Ministry for the Environment (MfE) emission factors.

Most of the benefit from increased recycling tonnage is the theoretical replacing of virgin material production.

Emissions associated with the collection/return, and disposal of materials included in the scheme are calculated. We have not been able to include embedded emissions associated with the required infrastructure in this calculation. We assume a cost of carbon of the midpoint of Treasury CBAx guidance shadow price projections.

As the approach is coarse, we have taken a conservative approach whenever a choice is required.

Table 20: Emissions categories ($ millions, 30 year PV 5% discount rate)

Emissions category	Glass in
Household transport	10.6
Landfill	-3.0
Virgin material	-65.4
Export of material	2.4
Decreased consumption	-0.8
Total	**-56.2**

Note: negative values are a reduction in total emissions compared to status quo and hence represent benefits

Household transport costs of $10.6 million

We use the emission factor of 0.207kg CO_2-e/km for a standard petrol vehicle and model an additional 14 million kilometres in year 1 and 21 million kilometres in year 5 once the CRS is in the steady state. These inputs result in costs of $0.3 million in year 1 and in year 4. Costs for the glass-out scenario are scaled by a factor of 0.54 to reflect reduced volume and weight.

Table 21: Additional household travel from CRS

Return depot type	Distance (km)	Trips per year	New trips	Km/year per household
RVM	5	26	10%	13
Manual	20	8	10%	16

Landfill emissions $2.5 million benefit

We calculate the change in emissions caused by a reduction in material going to landfill. LPB is assumed to be 88 per cent cardboard and 12 per cent plastic and aluminium. Other materials are considered inert and result in negligible landfill emissions.

Substitution of virgin material results in $65 million benefit

Only the additional recycling tonnages collected by the CRS system and reprocessed results in a net emissions reduction. The per-tonne emissions of recycling (the carbon saving from replacing virgin materials in production with recycled materials) is only estimated for aluminium. Glass is excluded from this calculation as it is assumed the CRS will result in increased glass crushing rather than an increase in bottle-to-bottle recycling. While for plastic European estimates using one tonne less of plastic packaging can result in a saving in the order of 3 tonnes CO_2e, and recycling the same type of material might result in a benefit of around 0.5 tonnes CO_2e per tonne of plastic, we have not applied these estimates to the New Zealand context (Hogg & Ballinger, 2015).

Export of material cost $2.4 million

Increased tonnages from refuse and litter are multiplied by the containership average emissions rate CO_2e per tonne kilometre. The distance is an average of Asian destinations in Table 22.

Table 22: Export rate of recycled material

Material	Rate	Tonnes once fully implemented
HDPE	0%	0
PET	0%	7,788
LPB	60%	3,007
Metal (aluminium)	95%	4,189
Glass[13]	0%	43,737

Source: Tranche 1 p.19-23, Sapere analysis

Destination of material is assumed to be an average of the following Asian countries.

Table 23: Destination assumptions

Destination	Nautical miles	Kilometres
Malaysia	5,016	9,290
Vietnam	5,398	9,997
Thailand	5,739	10,629
Indonesia	3,508	6,497
Average	4,915	9,103

Source: sea-distances.org

Decreased consumption benefit of $0.8 million

The CRS price increase is modelled to reduce sales of all beverage containers by 6.5 per cent. This is considered a one-off reduction in year 1. We have not attempted to model the loss of consumer surplus from the reduction in consumption, as we do not have sufficient information on the demand curve for beverages. Moreover, at least some of the loss would be made up by consumption of other goods. Finally, we have not sought to model any public or personal health or other effects from reduced consumption of alcohol or sugary beverages, which would also tend to offset any loss of consumer surplus. The inverse with healthy beverages would also need to be considered.

[13] Analysis assumes onshore crushing of additional glass recovery, the application of an eco-modulation fee could increase costs for glass export.

Qualitative assessment

In addition to the effects outlined above, co-benefits also arise from a CRS. The major co-benefit relates to additional recycling of non-CRS materials as a result of CRS collection depots or hubs having the potential to become a "drop-off" service for a broader range of materials. The key issue for such analysis was the ability to determine the extent to which whether any non-beverage container recycling that does take place at the "drop-off" was over and above what would have happened in the absence of a CRS.

Support for charitable objectives

Experience in South Australia suggests that voluntary and/or charitable organisations are able to capitalise on a CRS to boost their fundraising activities. Scouts in particular are frequently mentioned as major beneficiaries of a CRS. This can occur either in terms of such organisations establishing collection points or through the redemption of containers that are donated by others or sourced directly. In CBA terms, the degree to which people voluntarily donate their containers to charitable organisations is effectively a transfer (i.e. it does not alter the resources available to the economy in any meaningful way). As such, a CBA does not account for such transactions. As discussed in relation to employment, where organisations establish operations to undertake other activities that have financial reward, these undertakings are captured in terms of resources invested (i.e. opportunity costs) and outputs from the activities (i.e. increased recycling and/or avoided costs of landfill). Separate consideration of such impacts would risk double-counting.

There may be some argument that revenue raising through a CRS means that volunteer or charitable organisations are better able to supply services or could reduce their reliance on other fundraising actions. The latter might give rise to the possibility of additional resources being made available to other charities (who might otherwise have given to the organisation who now has CRS-sourced revenue streams). In essence, this series of possibilities also represents wealth transfers from one party to another. To the extent that there is some additional well-being effect from the transfer, it is likely that it would be captured in the willingness-to-pay estimates summarised above. Again, our approach is to recognise the possibility of such effects, but not include such effects in the CBA.

Marine plastics reduction

Previously we monetised this benefit based on recent analysis that showed the total economic cost of marine plastic pollution in 2011 was US$3,300 to US$33,000 per tonne in the ocean (Beaumont, et al., 2019). We conservatively used the lower figure and equated to New Zealand dollar terms, adjusting for income differences and inflation, to arrive at a figure of $4,616 per tonne of plastic. We assumed 50 per cent of reduced litter would have entered waterways. This estimate was a more conservative adaptation of available evidence from Jambeck, et al., (2015) suggesting that 1.75 per cent of total production enters the ocean.

Peer review suggested this was speculative and queried the accuracy of the method. Upon review, we decided the uncertainty around how and when plastic litter is collected – including what washes up on the beach and is then collected, or what the differential impact is of plastic marine litter that sinks to the bottom of the ocean – makes this study of less value. Given the monetary value of this benefit is immaterial to the result, we highlight the reduction in marine plastic is a benefit rather than include a monetary value.

Net impacts

This section compares the benefits to the costs over the study period of 30 years. To be of most use for decision-makers, the estimated costs and benefits are expressed in present value terms, using a discount rate of 5 per cent. A three-year phase-in period is assumed.

Table 24 shows a net benefit to society of around $1,391 million and benefits exceed costs by 61 per cent. The result represents the midpoint of a range of willingness to pay benefits that deliver net benefit between $100 million and $2,682 million, meaning benefits exceed costs by 4 per cent to 118 per cent.

We reiterate that these results are measured against a 'business as usual' scenario where there is no CRS; therefore, no change is assumed in the return rates or methods of collection and disposal than is presently the case.

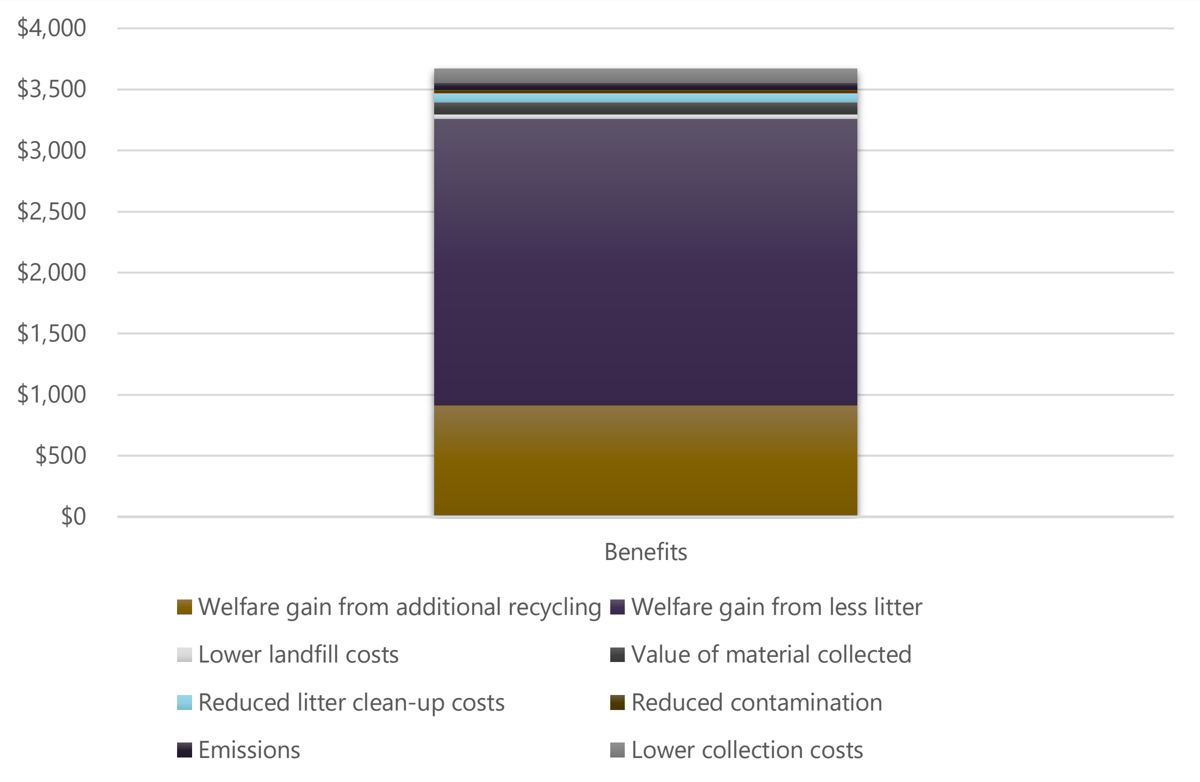
Table 24: Summary CBA results (PV, $m)

Category	Value
Total benefits	$3,667 ($2,376 to $4,958)
Total costs	$2,276
Net benefits	$1,391 ($100 to $2,682)
Benefit-cost ratio	1.61 (1.04 to 2.18)

Gains in welfare responsible for 89 per cent of total benefits

Figure 1 shows that the major benefit category is the welfare gain to households from a reduction in litter following the introduction of the CRS. On its own, this benefit category accounts for about 64 per cent of the total estimated benefits. When combined with the welfare gain to households from additional recycling, the welfare gains account for 89 per cent of total benefits. Given the magnitude of this impact a range of sensitivity analysis (BCR sensitive to litter metric used) has been conducted and ranges are reported in brackets to indicate the uncertainty around these calculations.

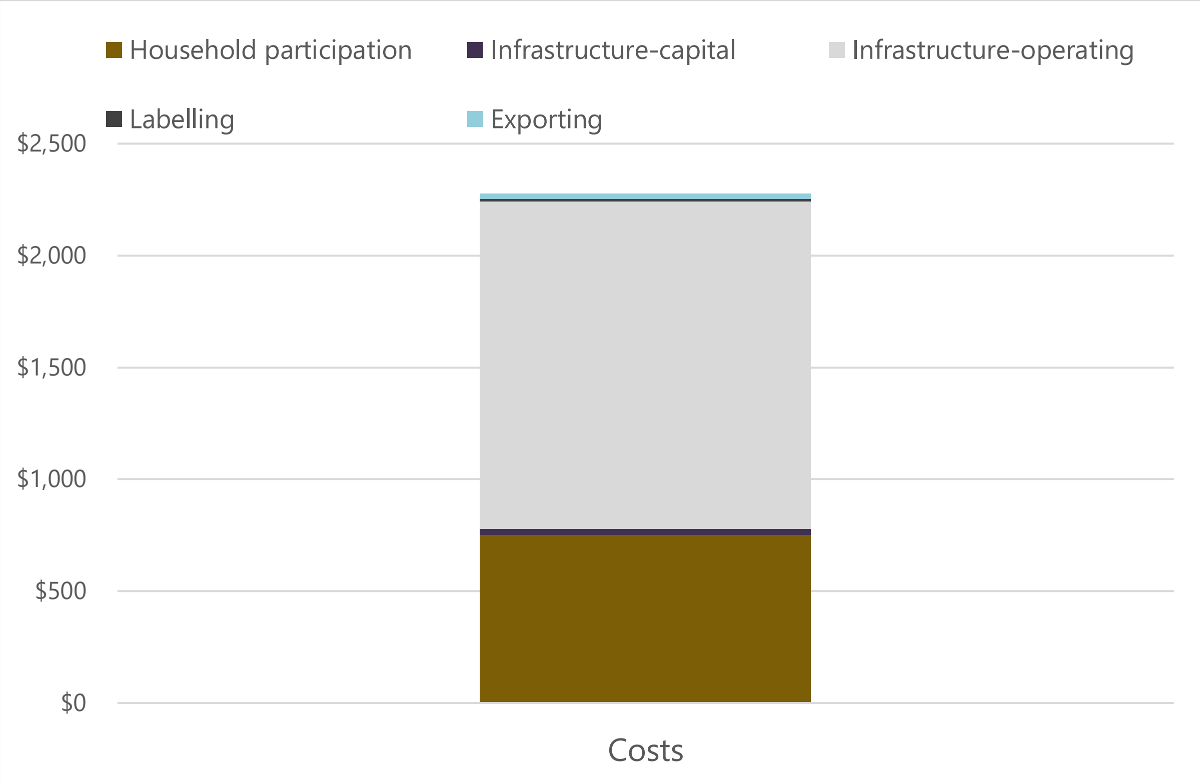
Figure 1: Composition of benefits (PV, $m)



Total costs are dominated by MCF and Collection Facility costs

Figure 2 shows the composition of costs for the glass-in and glass-out scenarios. The lion's share of costs relates to the operations of the MCF and collection depots (around 64 per cent of total costs). Household participation costs represent around 33 per cent of total cost.

Figure 2: Composition of costs (PV, $m)



Basic results mainly robust to sensitivity analysis

We subjected the results above to changes in some key assumptions. While there is an array of possible changes, for simplicity we focus on changes to the:

- analysis time period
- discount rate
- method of measuring litter
- optimum bias
- litter reduction beyond beverage containers
- weight-based factors driving key benefit estimates.

We present effects on the benefit-cost ratios (BCRs) but can report additional values, if required.

Timing and discount rate changes

The following two tables outline the effect of separate changes to the relevant parameters. The effect of shortening the study period is to lower the BCR, while the opposite effect is observed for reducing the discount rate.

Both changes are largely immaterial. This is not surprising given the ongoing nature of both benefits and costs. That is, rather than being a capital-heavy undertaking with significant costs incurred close to inception and then falling away until asset renewal is required, the majority of costs are operational in nature and continue to be incurred over time, much like benefits which continue to accrue across time. Thus, any differential that might be brought about through the effect of timing and discounting is effectively nullified.

Table 25: Benefit-cost ratios for alternative time periods

Period	BCR
10 years	1.51
20 years	1.58
30 years	1.61
40 years	1.62
50 years	1.63

Table 26: Benefit-cost ratios for alternative discount rates

Discount rate	BCR
2%	1.64
4%	1.62
5%	1.61
6%	1.60
8%	1.58

BCR sensitive to litter metric used

Using the average beverage container litter reduction reported from jurisdictions with a CRS, we investigate the relative impact of the chosen litter metric and associated willingness to pay for reductions. The results of the sensitivity test are reported in Table 27, showing that if item count is used with only the PwC (2010) method, then the BCR dips below 1, meaning that the costs of a CRS outweigh the benefits. If weight is used as the metric to measure litter, the BCR is over 2, meaning benefits are over twice the costs of the CRS. Our preferred average measure represents a practical middle ground.

Table 27: Willingness to Pay litter reduction benefit with different metrics and studies

Litter metric	(PwC, 2010)		Wardman et al., (2011)		Average	
	30 year PV $m	BCR	30 year PV $m	BCR	30 year PV $m	BCR
Average	1,724	1.34	2,972	1.89	$3,667	1.61
Item	638	0.86	1,099	1.06	$2,188	0.96
Weight	2,653	1.75	4,574	2.59	$4,933	2.17
Volume	1,881	1.41	3,244	2.00	$3,882	1.71

Litter can be measured with a variety of metrics. Ultimately, we could not determine the best litter metric to use, because:

- weight places emphasis on heavier material
- item count places more emphasis on small pieces of litter that may not be as noticeable
- volume would place more emphasis on larger bulky containers.

Table 28: KNZB litter audit results

	Item count	Weight	Average volume	Average
Percent litter	9%	36%	26%	24%

Source: KNZB litter audit 2019

Table 29: Total litter reduction by different metrics

Beverage litter reduction	Item	Weight	Volume	Average
Low (35%)	3.1%	12.7%	9.0%	8.3%
Average (61%)	5.3%	22.2%	15.8%	14.5%
High (84%)	7.3%	30.5%	21.6%	19.8%

Stadium effect increases BCR

A simpler approach would be to apply the total litter reduction reported in jurisdictions with CRS in a blanket fashion. The reduction ranges from 30 per cent to 64 per cent, with an average of 47 per cent reported and could be associated with a "stadium effect".[14] The results are presented in Table 30. The 30 per cent litter reduction using the PwC (2010) study results in households' willingness to pay of $122 per year for the litter reduction.

Table 30: CRS induced total litter reduction

Total litter reduction	(PwC, 2010)		Wardman et al., (2011)		Average	
	30 year PV $m	BCR	30 year PV $m	BCR	30 year PV $m	BCR
30%	3,578	2.15	6,169	3.29	4,874	2.72
47%	5,606	3.04	9,666	4.83	7,636	3.93
64%	7,634	3.93	13,162	6.36	10,398	5.15

Analysis robust to recycling willingness to pay study applied

The availability of relevant studies of willingness to pay is extremely limited. We have found two studies, and one is based on Australian households' willingness to pay. Arguably, the results of the Australian study could be ignored in favour of the New Zealand specific study. We would support such an approach if a number of other relevant studies were available to draw from, but that is not the case. In our view, two data points are preferable to a single source, notwithstanding potential issues with the transfer of benefits from other jurisdictions. Table 31 shows the analysis is robust to either method.

Table 31: Recycling willingness to pay

Study	30 year PV $m	BCR
PwC (2010)	4,273	1.88
Covec (2007)	3,062	1.35
Average	3,667	1.61

[14] Packaging Forum spokeswoman Lyn Mayes recognises that when people see litter they could feel licensed to litter too, meaning less littering of one type leads to less littering of all types known as a "stadium effect" (Woolf, 2018).

Accounting for optimism bias, the BCR falls below 1 with 50 per cent adjustment

A response to the potential for households to overstate their willingness to pay for reduction in litter and increases in recycling is to allow for so-called optimism bias. Optimism bias has been known to reduce costs and inflate benefits. We model a range of bias values in relation to households' willingness to pay estimates. Table 32 shows it takes almost a 50 per cent reduction in willingness to pay benefits to result in net social costs.

Table 32: Optimism bias applied to willingness-to-pay benefits measures ($m, 30y PV)

Optimism bias	0%	10%	20%	30%	40%	50%
Recycling	913	822	730	639	548	456
Litter	2,348	2,113	1,879	1,644	1,409	1,174
BCR	1.61	1.47	1.32	1.18	1.04	0.89

Glass-out scenario

The relativity between the benefits and costs for the respective glass-in, glass-out scenarios highlight the predominance glass containers have with respect to gains in welfare from reduced litter and additional recycling, which are both calculated on a weight basis.

Table 33: Comparison of result for a CRS excluding glass (30 year PV)

	Glass-in scenario	Glass-out scenario
Total benefits	$3,667 ($2,376 to $4,958)	$1,753 ($1,130 to $1,386)
Total costs	$2,276	$1,587
Net benefits	$1,391 ($100 to $2,682)	$167 (-$388 to $671)
Benefit-cost ratio	1.61 (1.04 to 2.18)	1.10 (0.79 to 1.43)

Adjusting deposit levels

A high-level analysis of the impact of adjusting the deposit level through a range from 10 cents to 30 cents was undertaken by adjusting the assumed participation rate, diversion from kerbside collections and the expected rate of litter reduction. The intuition behind this change is that the deposit level acts as a participation incentive so adjustments will impact participation costs and diversion (from litter and kerbside refuse and recycling collections) rates.[15]

The core assumption for participation based on PwC modelling of return rate is a starting rate of 90 per cent of the expected steady state recovery rate. In this analysis we adjust the final participation from the core of 84 per cent down to 77 per cent for a lower deposit level, and up to 86 per cent for the higher deposit level, which adjusts household participation costs and the timing of litter reduction benefits.

For the 10 cent deposit level we assume litter reduction is reduced to the lowest level reported from international experience (35 per cent), resulting in a lowering of the litter reduction rate from 14.4 per cent to 8.2 per cent. This decreases the BCR to 1.20.

For a 30 cent deposit we correspondingly assume the highest rate of container litter reduction reported in international experience (84 per cent), resulting in a 19.8 per cent total litter reduction. This raises the BCR to 1.97.

Table 34: Deposit level sensitivity analysis ($ millions)

Steady state participation	Deposit level	Total benefits	Total costs	NPV (30 year)	Glass in BCR
77%	10 cents	2,622	2,183	438	1.20
84%	20 cents	3,667	2,276	1,391	1.61
86%	30 cents	4,551	2,304	2,247	1.97

[15] There is no empirical evidence we are aware of to assess the deposit level and litter reduction association. PwC has conducted regression analysis of 37 international schemes recovery rates in relation to deposit level and median household income that informs the PWC modelling.

Containers per tonne adjustment

Adjusting the assumptions around containers per tonne has little bearing on the model, as the most significant calculations are not influenced by this conversion factor. The change does increase household participation costs and manual return depot costs as both of these are determined by the number of containers. Hence, the BCR reduces to 1.57.

Table 35: Containers per tonne conversions

	(000's) per tonne (PwC financial model 2020)	(000's) per tonne (PwC & WSC, 2011)	PwC 2021
Plastic	24.230	24.607	
HDPE			15.030
PET			18.080
LPB	10.024	24.060	20.919
Metal (aluminium)	60.770	66.821	52.537
Glass	3.711	4.784	3.923
BCR	**1.61**	**1.57**	**1.61**

Source: (PwC & WSC, 2011)

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