A Container Return Scheme 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
PP&G	Paper, plastic and glass
PET	Polyethylene terephthalate
PSO	Product Stewardship Organisation
RF	Return Facility
RVM	Reverse Vending Machine
TLA	Territorial Local Authority
WG	Working Group
WtP	Willingness to pay

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 update relies on new financial modelling from PwC finalised in October 2022. That is, based on the expert input used by PwC, we largely take as given the design features, options and operations of a CRS.

Compared to a 'business as usual' situation of no CRS, a CRS would result in society being better off to the tune of $1,135 million, in present value terms over a 30-year time period. In that scenario, benefits exceed costs by 47 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 static counterfactual may or may not be realistic but is chosen for reasons of tractability. Attempting to model future possibilities in the absence of detailed information and accompanying data would introduce more uncertainty in an already changeable environment.

The central estimate of the major benefit categories (i.e., welfare gains from reduced litter and increased recycling) uses an average of willingness to pay studies. Using only the lower of these estimates for both litter reduction and increased recycling would result in $874 million net costs and applying only the higher estimates results in $2,592 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 complete – information. We present the midpoint results with a range in brackets. Our estimates are based on as wide a range of studies as possible. This broad approach is taken to avoid the possibility of spurious accuracy as a result of ascribing to a single source, the kinds of effects we expect in New Zealand.

These results are largely robust to adjustments to the time period, discount rate, participation rates and allowing for optimism bias on either benefits or costs.

Category	CRS estimates
Total benefits ($m, PV)	$3,524 ($1,515 to $4,981)
Total costs ($m, PV)	$2,389
Net benefits ($m, PV)	$1,135 (-$874 to $2,592)
Benefit-cost ratio	1.47 (0.63 to 2.08)

We are confident these figures are moving closer to the 'true' impact, accepting that further refinement and research is also needed to be definitive. In simple terms, the results are reasonable, though not perfect.

Introduction and background

This report is an update of the cost-benefit analysis (CBA) for a proposed New Zealand container return scheme (CRS) finalised in February 2022 for public consultation.

Key aspects that have been reviewed and updated include:

- new willingness to pay (WtP) evidence
- addressing gaps in data and uncertainty around material flows by changing our approach to estimating litter volumes
- updated financial modelling from PwC received October 2022 for the expected:
  - container return rate
  - start date, which changes the impact of discounting
- further consideration of distributional effects
- participation and redemption rates.

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

A 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 to 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.

How a CRS works

At its core, a CRS provides an incentive to encourage people to return empty drink containers to specified collection points. A stylised representation of how a CRS works is shown below (see Figure 1). It shows the main players and the monetary and materials flows involved.

Figure 1: How a CRS works

Source: Envision (2015) Note Managing Agency is now referred to as the Product Stewardship Organisation (PSO)

In general, material flows are "one-way" in nature, with a single exit point to end users/markets where the relevant material is sold for re-manufacture into new containers or for other uses.

On the other hand, monetary flows mostly involve "multilateral exchanges" of the deposit among parties, though not necessarily contemporaneously. For instance, a consumer pays the deposit amount to a retailer upon purchase. The retailer had previously paid the deposit amount attached to that container to the beverage (or container) producer, who in turn had previously passed the deposit amount to a Product Stewardship Organisation (PSO).

This analysis follows previous work

Auckland Council 2016

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.

Waste Minimisation Fund 2019

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 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 in 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.

Ministry for the Environment February 2022

Continuing the process of review and refinement, the previous CBA was amended in February 2022 to reflect updates to the system design and financial modelling from PwC. This update incorporated changes to design decisions and updates to primary sales and kerbside recycling data. As in the previous version of the analysis, the inputs from PwC financial modelling are used as the basis for the economic analysis.

Fresh milk containers were previously included; they were now proposed to be excluded. This proposal changed the volume of plastic containers included. Specifically, most HDPE beverage plastic was excluded from the CRS.

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

There were also significant changes to capital costs for the Material Consolidation Facilities (MCFs), the forecast growth rates for container numbers, and 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 volume change has a negligible impact on overall recycling estimates.

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

Compared to a 'business as usual' situation of no CRS, a CRS was found to result in society being better off to the tune of $1,391 million, in present value terms over 30 years. In that scenario the BCR was 1.61, meaning modelling produced benefits exceed costs by 61 per cent.

Data is imperfect and participants' responses uncertain; we rely on simplifying assumptions

While this iterative process has increased the certainty associated with the estimated costs and benefits of the CRS, there are several 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 unknowns meaning assumptions are required. These assumptions reduce the accuracy of estimates.

Commercial recycling 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

[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. However, it is likely some of the unknown volumes are currently from commercial collection streams likely going to landfill and these unknowns are modelled to be diverted into the CRS at the assumed participation rate.

(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 in consumption (Queensland Productivity Commission , 2020). This is a simplifying assumption used in the PwC (2021) financial modelling. We test this assumption in sensitivity and find a relatively minor impact see section heading: Adjusting demand response has little bearing on core parameters. There are differences in the proposed deposit level and 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.

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 in line with legislative/regulatory requirements, so we have avoided speculation on compliance, 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:

- Product Stewardship Organisation (PSO) that oversees the operation and administration of the scheme.[2]
- Material Consolidation Facilities (MCF) that collect, aggregate, and bale returned containers for sale and processing.
- Return Facilities (RF) are locations for consumers to return containers for deposit refunds.

Costs for the PSO and MCFs were provided by the 2021 PwC financial model and updated in 2022, 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 capacities. 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 a 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.[3] 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

[2] Previously referred to as the Managing Agency

[3] The importance of this assumption is investigated in sensitivity testing.

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, it is expected that beverage containers will be diverted from kerbside refuse and recycling collections, and the quantity of beverage containers that become litter will be reduced.

A key change to analysis in this update is the assumptions around how to deal with the large proportion of unknown volumes. Previously it was assumed half the unknown volumes would be diverted into the CRS at the rate of litter reduction found from evidence of schemes in Australia and the United States (61 per cent of beverage container litter, for a total litter reduction of 14.5 per cent). This update assumes all the unknown volumes will be diverted into the CRS at an average of the Canadian redemption rates (80 per cent).[4]

Table 1: BAU volumes in scheme period 1, (2026)

Material flows	Tonnes	Percentage	CRS impact
Containers sold	317,546	100%	6.5% reduction (excluding milk)
Kerbside recycling	120,425	38%	80% diversion to CRS
Kerbside refuse	23,998	8%	80% diversion to CRS
Kerbside contamination	15,856	5%	50% reduction to CRS
Commercial recycling	23,719	7%	No change
Unknown flows	133,548	42%	80% diversion to CRS

Source: PwC 2021 financial model, Sapere analysis.

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

- 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.

[4] These assumptions are tested in sensitivity

- The average population growth rate used over the core 30-year analysis period is 0.59 per cent in line with the latest PwC update.

The 2021 financial modelling assumed 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 2022 updates increased the expected return rate to 90 per cent and phased this in over five years.

The financial model return rate was used as a proxy for the household participation rate which was used to estimate the diversion rate from kerbside collections. This meant in year 1, 75.5 per cent of households would divert beverage containers from kerbside refuse and recycling into the CRS, and by year 4, 83.9 per cent of household beverage containers were diverted from kerbside collections, and this rate continued for the 30-year modelling period.[5]

In this iteration of modelling, the average of all Canadian CRS redemption rates is used as a proxy for household participation rates. For the purposes of this CBA, the rate is phased in over five years, meaning in year 1 household participation is modelled at 67 per cent and by year 6 a steady state of 80 per cent is achieved. This rate is used to estimate diversion of containers from kerbside collections and the unknown volumes.

Litter is modelled to reduce by 61 per cent once the CRS is fully implemented. 50 per cent of this reduction happens in year 1 and increases at 10 per cent per year, so 100 per cent of the litter reduction occurs by year 6. Establishing a baseline for the level of litter was challenging. Previously we assumed that half the unaccounted-for container volumes became litter. This assumption aligned roughly with the Keep New Zealand Beautiful (KNZB) national litter audit that reported a total of 190,000 tonnes of litter was collected in 2016. The 2019 KNZB survey finds 36 per cent of litter by weight is beverage containers, which equates to 69,000 tonnes (using the 2016 value). If the average of metrics (item, weight, and volume) is used, this results in around 45,000 tonnes of beverage container litter. Beverage litter was modelled to reduce by about 26,000 tonnes in year 1 and around 42,000 tonnes once the full impact is achieved. However, 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. It does impact the change in recycling volumes and therefore the WtP for increased recycling.

To avoid this potentially contentious assumption, we developed an agnostic approach to unknown material volumes origin. Instead of calculating the tonnes of litter diverted into the CRS, we now assume 80 per cent diversion on the total unknown volume. This is based on analysis of other scheme deposit levels and return rates – see Table 2 below. The average of the Australian schemes redemption rates (68 per cent) is considered more appropriate for a 10-cent deposit, the Canadian average of 80 per cent aligns closest with the 20-cent deposit and the 91 per cent return rate reported in Europe seems more appropriate for a 30-cent deposit. Clearly this assumption is not a perfect representation of expected participation rates and diversion of unknown flows; however, we

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

considered it a pragmatic approach. For modelling consistency, this rate is used as a proxy for the household participation and diversion from kerbside collections. We test this assumption in sensitivity – see heading: BCR robust to adjusted deposit levels.

Table 2: Other scheme deposits and return rates

Region	Average return rate	Average deposit (NZD)
Europe	91% (n=10)	29 cents
Canada	80% (n=11)	22 cents
USA	70% (n=10)	12 cents
Australia	68% (n=6)	11 cents

Source: https://www.reloopplatform.org/wp-content/uploads/2020/12/GDB-2020-Grid-of-Comparison-7DEC2020.pdf Note there are likely differences in calculating return rates including some based on volume and others weight.

Previously return rates were 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 used household participation rates to assume the volume of material that is diverted from kerbside refuse and recycling schemes into the CRS.

Average of Canadian redemption rates used for household participation rate

As mentioned above, we developed an approach that removes the need for the contentious litter volume assumption. This means we cannot calculate the net impact from the diversion; that is, we don’t know if the material was coming from litter, landfill, or some other source.

- The main implication is we do not calculate an offsetting value, e.g., a reduction in landfill costs, as we do not know the origin of some of the material diverted into the CRS.
- The WtP for litter reduction calculation is unaffected by this change in assumptions as it is based on a percentage reduction in litter.
- The WtP for increased recycling total benefit increases as the previously ignored volume is assumed to be diverted into the CRS and recycled.
- We add a calculation for collection costs on this volume of three seconds per container.
- Assumptions and volumes for diversion from kerbside collections are now based on the lower Canadian redemption rates (80 per cent) rather than the desired return rate previously used (90 per cent).

- This set of assumptions results in the recovery rate increasing to 90 percent once the fully impact of the CRS is phased in as shown in Table 3.

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

Category	Year 1 BAU	Year 1 CRS	Year 5 BAU	Year 5 CRS
Total consumption	317,550	310,080	326,534	318,852
Total recycling	144,144	256,639	148,222	281,406
Recovery rate	**45%**	**83%**	**45%**	**88%**[6]

Source: Sapere analysis, PwC 2022 financial model used as material flow inputs

[6] Once fully phased in Year 6 the steady state recovery rate is 89.8 per cent

Relevant costs and benefits

The categories of costs and benefits included in this analysis are summarised in Table 5.

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.

The 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 5). 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).

Previously we used two studies that sought to quantify/monetise such amenity benefits that have been frequently cited in analysis of CRSs[7] and other waste management projects.[8] PwC (2010) is an Australian study and Wardman et al., (2011) is 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.

As part of the public consultation process more recent studies were identified. This prompted a review of WtP evidence and the decision to replace the Wardman et al. (2011) study with a more recent and comprehensive one (Cherchi, et al., 2020). We also include a Centre for International Economics (2022) Australian study. That is, we now use an average of three studies to estimate WtP for litter reduction.

We assessed the studies based on context, plausibility, method, and availability of alternatives. Some of the key attributes are presented in the table below.

[7] See NSW EPA, (2017); Government of Western Australia (b), (2018); ACT Government, (2018).
[8] Such as Perry, Varua, & Hewitson, (2018)

Table 4: Willingness to pay studies summary

Study	Relevance and value	Assessment	Comment
PwC (2010)	WtP for litter reduction - based on national sample of Australian households found willingness to pay, on average, $4.15 per 1% point reduction in litter.	Widely used in other jurisdictions' CBAs on CRS as was one of the only sources of WtP estimates available. As a sense check it roughly equates to recent NZ survey of litter values Horizons (2021).	Respondents could have pegged their valuations on two discrete levels of litter reduction (respondents were informed that the 10% reduction corresponds to a 'noticeable improvement' and a 20% reduction corresponds to a 'significant improvement').
	WtP for increased weight recycled-based on national sample of Australian households found willingness to pay, on average, $2.77 per year for every 1% increase in the weight of waste packaging recycled, above the current national average level of recycling of 55%.	While somewhat dated it is one of only two sources found that estimate the value of increased recycling.	The PwC (2010) paper has several issues that have been highlighted by others,[9] but it remains one of the only estimates of WtP for increased recycling.
CIE (2022)	WtP for litter reduction – reduction in litter by 20% valued at average of $21.9 per household per year.	A recent Australian study where peer review found the techniques used in the study go beyond commonly established practice and include approaches at the forefront of the discipline (e.g., nonmonetary contingent valuation and BW-scaling calibrated to WTP from CV), considered state of the art.	The approach raises some additionality questions. Are the change in the number of sites with litter and the change in composition of litter complementary or substitutable in terms of the welfare impact? Due to the local context of CRS already established in 2 of 3 states studied we use the values for the state without a CRS.

[9] See http://nepc.gov.au/system/files/resources/0c513e54-d968-ac04-758b-3b7613af0d07/files/bevcon-rpt-abarefinalreviewreport-201006.pdf

(Cherchi, et al., 2020)	WtP for beverage container litter reduction. The (mean) value for an 85% reduction in beverage container litter was approximately £62 per household per year – around 0.2% of median household income in England.	Produces very similar values to study previously used (Wardman, Bristow, Shires, Chintakayala, & Nellthorp, 2011). More recent and robust study that specifically looks at value of reduction in beverage container litter.	The survey design, implementation and analysis followed good practice guidance. The stated preference survey questionnaire and supporting material were subject to an iterative testing process to demonstrate respondents interpreted the choice scenarios as realistic policy options, and that the choice tasks were understood.
Covec (2007)	WtP for increased recycling. Produces a conservative midpoint value of $183 per tonne based on time cost of $5.20 per hour which is updated to $373 per tonne based on time value of $10.63.	Only New Zealand specific study but does not include metal and is tonnage based so likely overstates value associated with heavy materials or understates value of lighter materials.	Used time conversion in attempt to control for WtP studies generating values higher than actual WtP. Average respondent was willing to spend longer recycling than they did currently. Very conservative application of values produced.

Willingness-to-pay surveys have been accused of producing overstated 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. 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 concerning the type of direct consumer benefits under study here is whether they are added 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 added 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).

Table 5: 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 the proportion of participating households.	NZTA Economic Evaluation Manual, author's estimates. Australian redemptions rates are used as a proxy for household participation rate.
Infrastructure-capital	Asset costs for processing and collecting containers for MCFs.	Estimated market cost of assets.	PwC (2022), Author's estimates
Infrastructure-operating	Transport, administration, handling, and processing/staff costs for MCFs, collection facilities, and Product Stewardship Organisation (PSO).	Cost per tonne for transport and handling. Annual estimated labour and other costs.	PwC (2022), 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 the 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 (2022)

	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 three sources used.	PwC (2010), (Centre for International Economics, 2022), (Cherchi, et al., 2020)
Lower landfill costs	Avoided costs of landfill due to tonnes diverted from kerbside refuse.	Diverted volume multiplied by the cost per tonne of landfill.	PwC (2022) CBAx tool (2022)
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 (2022)
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

	Description	Calculation used	Source
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. The largest impact stems from replacing virgin material.	The 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
Lower collection costs	Savings from a reduced burden of kerbside collection.	Reduction in volume of kerbside refuse and recycling multiplied by cost saving per tonne.	PwC (2020), Covec (2016)

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 6. We highlight that, where value ranges are presented, we use the midpoint for modelling purposes.

Table 6: Core assumptions

Relevant factor	Value	Source
Discount rate	5%	Treasury (2021)
Study period	30 years	Author's estimate
Phase-in period to steady state	5 years	PwC (2022)
Average annual household and consumption growth	0.59%	Statistics New Zealand, PwC (2022)
Maximum household participation	80%	Average of Canadian redemption rates used as proxy for participation rate

Total costs of $2,389 million

Modelling estimates the CRS to cost almost $2.4 billion over 30 years, with household participation (time and travel) costs the largest single category of costs at $847 million. Combined operating costs are almost $1.5 billion with Return Facilities ($571 million), Material Consolidation Facilities ($546 million), and the Product Stewardship Organisation ($360 million) the highest components.

Table 7: Summary of costs (30-year Present Value)

Cost categories	Value $ millions
Product Stewardship Organisation	360
MCF capital costs	23
MCF operating costs	546
Return facility costs	571
Participation costs	847
Labelling costs	10
Exporting cost	32
Total costs	**2,389**

Material Consolidation Facilities capital costs of $23 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[10] (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 8).

Table 8: Capital costs for MCF (PV, $m)

Category	Cost	Asset life
Long-term assets (balers, conveyors and silos)	$19.0	35 years
Short-term assets (conveyor belts)	$0.2	4 years
Land	$3.6	1.9ha at $186m^2
Cages	$4.5	35 years

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

[10] 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.

Operating costs of $1,477 million

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

Product Stewardship Organisation costs total $360 million

Table 9 outlines the PSO operating costs for the initial implementation phase and the 'steady state' or ongoing yearly costs.

Table 9: Product Stewardship Organisation fixed costs (PV, 2021 $m)

Year	Zero	One	Ongoing
Admin and support services	-	$11.6	$9.3
Professional services	$9.8	$4.0	$2.4
Marketing and communication	-	$5.8	$4.6
Employee benefits	$0.3	$3.9	$3.9
Other expenses	$1.7	$7.0	$7.0
Office lease	-	$0.2	$0.2

Source: PwC 2021 financial model

Material Consolidation Facilities costs total $546 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 for the required services.[11]

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 near capacity and some of the additional glass returned due to the CRS would need to be crushed in the absence of any other regulatory or system changes. We assume a constant 30,000 additional tonnes per year can be recycled and the rest crushed.[12]

[11] Whether this is practical remains to be seen and is a matter for the future Product Stewardship Organisation to determine, alongside other considerations such as fraud risk management

[12] Rather than crushing surplus glass, recovered glass could be shipped to Australia or Asia, an eco-modulation fee structure would likely be needed to deliver this outcome.

Table 10 shows that total transport and processing costs are estimated to be $373 million. The glass cost per tonne figures are at the high end of the ranges considered, possibly overstating the true costs of glass transport and processing.

Table 10: Transport and processing costs

Category	Cost per tonne	Steady-state cost (PV, $m)	30-year cost (PV, $m)
Transport (plastic, metal, LPB)	$175	$3.9	$82
Transport glass	$112	$13.9	$289
Glass crushing	$90	$4.0	$84

Source: PwC Financial modelling final report July 2020 and PwC 2022, Sapere analysis

Staff and utilities costs are estimated at $90 million, based on financial modelling by PwC that uses escalators to increase costs with material throughput.

Table 11: Variable costs per MCF (PV, $m)

Category	Initial costs	30-year cost (PV, $m)
Staff costs	$5.4	$77
Utilities costs	$0.9	$13

Source: PwC Financial model 2022

Return facilities costs total $571 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, 810 return facilities (102 OTC, 51 automated depots and 657 RVM locations) are included in year 1 of the modelling and increase in a constant ratio with population growth. As indicated earlier, RVMs account for 85 per cent of facilities container volume and the remaining 15 per cent go to OTC and automated return depot facilities.

The model has the costs of leasing and maintaining the RVMs fixed but the number of RVMs growing with population. Our calculation of economic cost per container for RVMs drops as the CRS is implemented, then stays relatively constant. In year 1, RVMs cost 2.6 cents per container, while by year 6, when the system is fully implemented, the cost per container is 2.2 cents.[13] The assumption for OTC and automated depot return facilities is a constant 3.0 cents per container. This figure is lower than the costs used by PwC as their costs were financial in nature and included elements such as taxes which are immaterial to an economic analysis (focussed on resources available to the economy rather than wealth transfers between parties).

[13] This is calculated by the total RVM lease cost per year divided by the number of containers processed.

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 return depots 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 $463 million, based on a lease model

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

A leasing model is used for the RVM return facilities. While many iterations 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. The 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[14] and inflate to 2021 dollar terms for a lease cost of $14,762 per RVM per year.

2200 RVMs required

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

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 from the proposed design. The nature of the broader mandatory Scottish model means there is likely to be 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 ($37 million) and automated depot facilities ($71 million) cost $108 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 12). 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. There is some anecdotal evidence indicating Australian return facilities can be quite profitable.

Table 12: 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 $10 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. Estimates based on (Hogg & Ballinger, 2015).

Exporting costs of $32 million

The total additional tonnes of recovered material that is exported for processing is multiplied by the costs provided in PwC's financial model. LPB is exported at a cost of $190 per tonne and metal at $100 per tonne (PwC, 2022). It is possible emerging New Zealand infrastructure will see local demand for this material rise and reduce costs.

Participation costs total $847 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.

We also add a collection time cost to the containers modelled to go into the CRS from an unknown origin.

Any changes in costs to households/consumers from the scheme passed on to consumers as price increases are highly uncertain. At 100 per cent pass through of cost to consumers, financial modelling assumes a 21 cents (excluding GST) per container cost in year 1 which rises to 30 cents by year 30 from the scheme, whereas the economic cost is estimated as the cost of the Product Stewardship Organisation, Return Facilities and Material Consolidation Facilities.

Household time cost of $422 million

As a result of the CRS, households are likely to spend additional time to 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 Over The Counter drop off points (manual).

Table 13: 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 **over two hours per year** participating via RVMs once the CRS is fully up and running, made up of around 1.35 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 return 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, 5 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 $345 million.

Transport cost $304 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 14 summarises the transport-related costs.

Underlying assumptions are set out further below.

Table 14: Breakdown of household transport costs (PV, $m)

Component	Value
Vehicle operating costs	$215
Time in car	$89

For consistency 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).
- However it is likely less RVM trips will represent new trips than for depot and manual OTC returns.

Table 15: Distance and frequency assumptions for participation cost estimation

Return point type	Share of returns	Distance (km)	Average speed (km/h)	Time per trip (minutes)	New trips per year	Minutes per year
RVM	85%	5	30	10	2.6	26
Manual OTC	5%	20	50	24	0.8	19
Automated depot	10%	20	50	24	0.8	19

Collection costs of $122 million

As a result of the agnostic assumption, we have conservatively added a three-second-per-container collection time cost for all containers diverted from an unknown source.

This is calculated through a simple formular of the number of containers times three seconds per container multiplied by the value of time $10.63.

Benefits total $3,524 million over 30 years

Total benefits are estimated to be over $3.5 billion over 30 years. The largest categories are the welfare gains from a reduction in litter and increased recycling.

Table 16: Benefits summary (PV 30 year total)

Benefit category	Value $ millions
Welfare gain from increased recycling	1,910
Welfare gain from reduced litter	1,042
Value of additional material recovery	216
Litter clean-up costs	57
Litter volunteers	4
Avoided landfill costs	38
Kerbside collection savings	91
Reduced contamination of recycling	30
Emissions	137
Total benefits	**3,524**

Welfare gain from increased recycling is $1,910 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 the 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 6 is $82 per household in nominal terms per year for increased recycling.[15]

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

[15] All household willingness-to-pay values per year in steady state are reported in nominal terms, real terms almost halve these values.

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.

This benefit value has increased due to volume increases from including the 50 per cent of unknown volumes which were previously excluded, and increasing the diversion rate from 61 per cent for litter to 80 per cent based on Canadian redemption rates.

Using one study produces benefits of $3,205 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 $3.09 per percentage point increase in current recycling rates. The CRS is modelled to increase the indirect recycling rate by 44 per cent once fully implemented, which translates to households being willing to pay $137 per year for the increase in recycling from indirect sources such as litter, recycling contamination, and kerbside refuse.

Using another study results in benefits of $614 million

Covec (2007) calculated consumer surplus by subtracting the time currently spent recycling from that which survey respondent indicated they are willing to spend. The average consumer surplus found was 10.1 minutes per week, which translated to $0.88 per household per week (using $5.20/hr for the value-of-time). To estimate a willingness to pay per tonne of waste, the author investigated several interpretations. 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 (Covec, 2007).

Table 17: Covec (2007) 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

Source: (Covec, 2007)

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 paper, plastic and glass, which implied a surplus of $350/tonne (based on 4.8 kg per week), thus the author considers the values used above as likely to be conservative.

Using the EEM cost update factors to adjust the $5.20 figure used for the value of time to $10.63 per hour resulted in a medium value per tonne of $373. This led to a willingness-to-pay figure of $26 per household per year and total benefits of $614 million. This method would seem to understate value as it does not include aluminium cans, which would likely be part of the CRS. Also, as the author states, the medium value is likely conservative given the alternate estimate that is closer to the higher value.

Once fully implemented, the modelling conducted (which considers likely transfers from kerbside refuse and reduction in litter and recycling contamination) results in the CRS increasing recycling of beverage containers by around 140,000 tonnes per year.

Welfare gain from reduced litter is around $1,042 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 three separate sources.

Table 18 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. [16]

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. See Appendix A for more details.

Table 18: 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

[16] 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.

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.

The litter reduction benefit is phased in over a five-year period with 50 per cent of the benefits occurring in year 1 and increasing at 10 per cent per year so the full impact occurs in year 6.

Benefits of $1,593 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 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 $4.64. A 14.5 per cent reduction in litter would result in households being willing to pay $67 per year.

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

Benefits of $1,203 million estimated in another study

Cherchi et al. (2020), a UK-based study for the Department for Environment, Food and Rural Affairs (DEFRA), found a (mean) value for an 85 per cent reduction in drinks container litter was approximately £62 per household per year, about £5 per month, around 0.2 per cent of median household income in England (Cherchi, et al., 2020).

Equating to New Zealand dollar terms, adjusting for income differences and inflation, results in a value of $70. Translating that effective 85 per cent reduction in beverage litter to the average of 61 per cent reduction found in international evidence results in an estimated WtP of $51 per household per year for the reduction.

Benefits of $328 million estimated in a third study

A Centre for International Economics (2022) report estimates WtP values for litter reduction across three Australian states. The study finds values differ across states (circa 50 per cent more in NSW than Queensland for litter reduction and a similar difference between Victoria and Queensland for the number of sites with litter) and attempts to value a reduction in total litter and separately the number of sites with litter, and it also explores how a change in litter composition is valued.

For benefit transfer, there are contextual considerations including whether already having a CRS impacts the relevant reported values (two of the three states surveyed implemented a CRS in 2017/2018). The study also raises questions around additionality: namely, does a CRS reduce total litter and the number of sites with any litter? We consider the state without a CRS as the most appropriate comparator, and while there is likely some additionality in the total litter reduction and number of sites with litter values, the potential additionality is best explored in sensitivity testing.

Translation of the value for total litter reduction from Victoria (the state without a CRS) by adjusting for income differences results in a value of around $14 NZD per household per year for a 14.5 per cent total litter reduction.

This excludes any value from a reduction in the number of sites with litter or from a change in the composition of litter. We expect these changes are likely outcomes from the introduction of a CRS so explore the impact of these values in sensitivity testing.

Additional value from material recycled is $216 million

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

Table 19 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.

Current glass bottle-to-bottle recycling is near capacity, so for the purposes of this CBA, only 30,000 tonnes per year of increased material is considered a revenue source with the rest, around 85,000 tonnes 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. It could also potentially be shipped to Australia or Asia, but that doesn't currently look financially viable (however, an eco-modulation fee structure could change this outcome). HDPE is milk container material so is also not included.

Table 19: Value of CRS materials recovered, PV

Revenue per tonne	$/tonne	Tonnes CRS steady-state	Value, $m per year
HDPE	$650	-	-
PET	$200	14,556	$2.9
LPB	$10	6,497	$0.06
Metal (aluminium)	$1,250	9,478	$11.8
Glass	$70	30,000	$2.1
Total		**60,531**	**$16.9**

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

Reduced contamination of kerbside recycling $30 million

Broken glass is a common contaminant. With the 80 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 the volume of contamination is multiplied by the landfill cost, $173 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 $91 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.[17] 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 20: Reduction in kerbside collection costs

Category	Tonnes CRS steady-state	Savings $m per year
Change in kerbside refuse	14,918	$1.1
Change in kerbside recycling	75,898	$4.8
Total change from CRS	**93,362**	**$5.9**

Source: Sapere analysis

Avoided landfill costs are $38 million

This is a simple calculation where tonnes of kerbside refuse diverted from landfill are multiplied by the $173 tonne[18] landfill cost (see Table 21). It ignores the likely scenario that some of the unknown volume will be diverted from landfill.

Table 21: Avoided landfill costs

Category	Tonnes CRS steady-state	Saving $m per year
Kerbside refuse diverted	18,414	$2.9

Source: Sapere analysis, PwC financial model

Reduced litter clean-up costs are $57 million

Estimated litter clean-up costs in Auckland are in the order of $11 million per annum, which equates to an average annual litter clean-up costs per person of $6.95, scaling to the national population generates a figure of around $34 million. We then apply a 14.5 per cent reduction scaled in at 50 per cent occurring in year 1 ($2 million) and 100 per cent in year 6 ($3 million) for a total present value of $57 million over 30 years.

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

[18] Based on CBAx (2022) with additional $10 as landfill levy expected to rise in 2024

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 $137 million

Greenhouse gas (GHG) emissions change because of the CRS in several key areas, not all of which are amenable to estimation. We consider:

- transport (additional household trips to return depots, transport of collected material from depots to MCF, transport of material to recyclers, local and international and reduced tonnes transported from kerbside and contamination to landfill)
- reduced consumption (the 6.5 per cent reduction in quantity due to price increase)
- reduced landfill emissions (from reduced liquid paperboard tonnes ending up in landfill)
- increased recycling (lower emissions than virgin material, increased transport to recyclers)
- embedded emissions (infrastructure required for CRS).

Due to lack of detailed data we have used a coarse approach relying on the Ministry for the Environment (MfE) emission factors. For modelling tractability, we assume an offset in transport emissions from the reduced transport to landfill and the increased transport to MCF and recyclers. We do measure the increase in household kilometres from new trips to return depots. We also measure the emission associated with shipping more material overseas.

We count a large benefit from increased aluminium recycling tonnage that is theoretically replacing virgin material production. As the approach is coarse, we have taken a conservative approach whenever a choice is required. 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.

Table 22: Emissions categories ($ millions, 30 year PV 5% discount rate)

Emissions category	Glass in
Household transport	-$9.5
Landfill	$4.0
Virgin material	$144.6
Export of material	-$3.2
Decreased consumption	$0.8
Total	**$136.7**

Note: negative values represent an increase in total emissions compared to the status quo and hence represent costs

Household transport costs of $9.5 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 16.5 million kilometres in year 5 once the CRS is in a steady state. These inputs result in costs of $0.3 million in year 1 and $0.4 million in year 5.

Table 23: 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 $4 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 $145 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 apart from an additional 30,000 tonnes it is assumed the CRS will result in increased glass crushing rather than an increase in bottle-to-bottle recycling, and we do not have the data to calculate this offsetting impact. 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) as emissions factors depend on the type of energy input and there is little evidence applicable to New Zealand.

Conservatively we have reduced the MfE emissions factor for aluminium from 11.8 to 9.04 CO2e per tonne based on UK GHG factor for difference between primary material and closed loop recycling. This is a rather coarse approach but shows significant emissions benefits likely as recycled aluminium can be 80 per cent of more less energy intensive than using virgin material.

Export of material cost $3.2 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 24.

Table 24: Export rate of recycled material

Material	Rate	Tonnes once fully implemented
HDPE	0%	-
PET	0%	11,614
LPB	60%	5,294
Metal (aluminium)	95%	7,574
Glass[19]	0%	93,882

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

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

Table 25: 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. The reduction in emissions is considered only for the reduced aluminium beverage containers of 1,032 tonnes.

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.

[19] 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 return 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 can capitalise on a CRS to boost their fundraising activities.

The NSW Return and Earn Scheme allows groups to become local donation partners (if they meet the eligibility criteria) and be one of the four charities on their local RVMs. Communities can choose to support a not-for-profit group from their local area by returning their eligible drink containers and donating their container deposit to that local group.

Scouts 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 a 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 that 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 as a benefit rather than include a monetary value.

Injuries and damage associated with litter

While we have estimated benefits from litter reduction associated with the dislike of experiencing litter there are potentially other benefits. Litter such as broken glass can cause injuries and property damage (for example bicycle tyre punctures). It logically flows that with a reduction in litter there would also be a reduction in injuries and property damage from litter.

Fraud - transporting containers from Australia

While fraud seems unlikely, high-level calculations show the proposed difference in deposit values between Australia and New Zealand makes it potentially profitable for those who could ship containers from Australia to New Zealand and then claim a higher deposit in that scenario. This would need to be in bulk format to avoid the country specific barcodes.

> "An empty soda can is about 14.7 grams. $0.20 NZD is $0.182 AUD, so the real difference in deposit is $0.082. Someone could earn $5,583 per tonne of crushed cans shipped across the Tasman. A standard 40' shipping container has volume of 2350 cubic feet, which on a rough measure could handle 3.3 tonnes of crushed cans. So a 40' container of crushed Australian cans is worth about NZD $18,800 in arbitrage." (Crampton, 2022, p. 9)

While crushed cans could not be redeemed in New Zealand by the public, this highlights the financial incentive and fraud risk associated with the increased value of the containers.[20]

Uncertainty and unknowns

There is still some uncertainty involved in the scheme costs that we have not been able to include in modelling such as space costs for RVMs, details on the collection and transport infrastructure required, and the nature of collection and processing contracts.

Collection trucks – operators may need to buy new trucks to empty RVMs. Costs of new vehicles could be up to $500,000 per vehicle with an expected depreciation of 10 years. CRS contracts might be for 5 years, meaning there may be issues with contracts relating to who is going to carry the risk of

[20] We found shipping costs advertised at around $5,100. https://www.youfr8.com.au/product-category/australia/sydney/new-zealand-brisbane-australia-sydney/auckland-destination-services-new-zealand-brisbane-australia-sydney/

the ongoing book value of specialist vehicles for the remaining 5 years if vehicles need to be purchased specifically for emptying CRS RVM bins.

Transport costs – Using a per-tonne approach may be a poor assumption for tractability as collection costs are often contracted on a per-lift basis.

Eco-modulation – The consultation document proposes that the scheme fees would be eco-modulated to improve waste minimisation and circular economy outcomes. This is a pricing mechanism that can be used to ensure materials are recycled. A fee can be modulated to reflect the costs of recycling a given product, and the fee typically increases when a product is hard to recycle. Equally, products that are easy to recycle have lower scheme fees, encouraging producers to use recyclable materials. The eco-modulation fee incentivises producers to improve the environmental sustainability of their product design.

If the scheme fees are eco-modulated, the fees paid by the producer would vary according to specific criteria relating to aspects of their products' environmental performance (eg, the waste hierarchy). There are several potential impacts such as a shift in container material type that have not been modelled.

Cost pass through

Under conditions of perfect competition, theoretical models predict a high rate of pass-through when demand is inelastic relative to supply. Available evidence (Australia) suggests a relatively high potential for producers to pass through the majority of the costs.

In a monopoly case, the pass-through rate in the benchmark linear model is 50 per cent and diverges either up or down depending on the curvature of the demand curve, potentially exceeding 100 per cent in some cases (i.e. over-shifting).

In practice, most segments of the drinks market will lie somewhere in-between the monopoly and perfect competition cases. However, the available oligopoly models do not provide a prediction of the extent of pass- through.

These issues are considered in sensitivity.

Regressive tax or charity and low-income support

Theoretically the increase in price will act like a consumption tax and could be viewed as regressive, with the highest impact felt by lower income groups. However, there are potentially some offsetting considerations. Higher income groups are likely less motivated to invest their time in collecting a refund so there is opportunity for a transfer of the deposit to lower income groups. We see some evidence of this in Canadian schemes that have developed into a mechanism for disadvantaged or vulnerable populations to supplement income.

Income opportunities for young and vulnerable

The Binners Project in Canada has reported success in improving the quality of life of its members. According to a recent survey homeless populations use waste recovery either as their primary means of income or to supplement government assistance. In a 2018 article, it was reported people could make between $20 to $60 per day, by collecting empty deposit containers. According to a study by Groupe interuniversitaire et interdisciplinaire de recherche sur l'emploi, la pauvreté et la protection sociale (GIREPS), University of Montreal, 44 per cent of people earning through container deposit returns used the income to cover their basic needs, including rent, food, transportation, etc.

Charitable fundraising opportunities

A CRS can provide financial benefit, through donation of deposits and fundraising to community groups, sporting clubs and charities that operate a depot, partner with an established depot or collect empty containers for refund. Any benefits to community groups and schools from a CRS could flow through to broader community benefits through the activities funded that otherwise might not have been.

Distributional considerations

The groups considered for the distribution analysis focuses on the following stakeholders:

- central and local government
- service providers (MRFs and return depots and RVM operators) waste contractors
- the food and beverage industry (producers, wholesalers, and retailers)
- households and the environment.

Table 26: Distributional considerations

Stakeholder	CRS impacts
Central and local government	The development and implementation of a CRS will affect government. Cost impacts are assumed to include costs for: • scheme development, including regulation and oversight mechanisms • approval responsibilities for container labelling • ongoing administration of the scheme • monitoring and enforcement. Benefits to local governments will result from reduced kerbside, litter collection costs, and landfill costs. It is assumed these are passed onto households through decreased rates.
Service providers (MRFs, return depots, and RVM operators)	MRF impacts include: • reduced processing and lost value of recyclates • benefit from increased revenue (handling fees and/or deposit redemptions) over and above additional operating costs. In the short term, benefits to MRFs may be elevated unless contracts are renegotiated with suppliers. Return depot and RVM operators will incur capital and operating cost impacts, but those costs are offset by the payment of handling fees. These costs are passed onto consumers through the scheme fees.

Food and beverage industry	The food and beverage industry will incur costs associated with the implementation of the scheme. It is assumed that these costs will be passed on to consumers.
Households	Consumer-related impacts include: • beverage price increases from pass through of scheme fees and deposit • participation costs • amenity benefits from reduced litter and increased recycling.

The key conclusions from the distributional analysis are:

- Consumers experience the highest costs – participation costs and increased prices.
- The environment receives the highest benefit of reduced litter and increased recycling – a benefit that is estimated as a change in consumer welfare.
- Return depot operators, MRFs and infrastructure providers (RVM and operators of new contracts, e.g. waste transporters, recyclers) benefit from the introduction of a CRS.
- Community and charitable organisations may also benefit from the scheme by using the scheme as another way to raise funds or receive donations, or by partnering with a network operator to operate return depots.

Net impacts

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

Table 27 shows a net benefit to society of around $1,135 million and benefits exceed costs by 47 per cent. The result represents the midpoint of a range of willingness to pay benefits that deliver net costs of $874 million and net benefits of $2,592 million, meaning benefits are only 63 per cent of costs or exceed costs by 108 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.

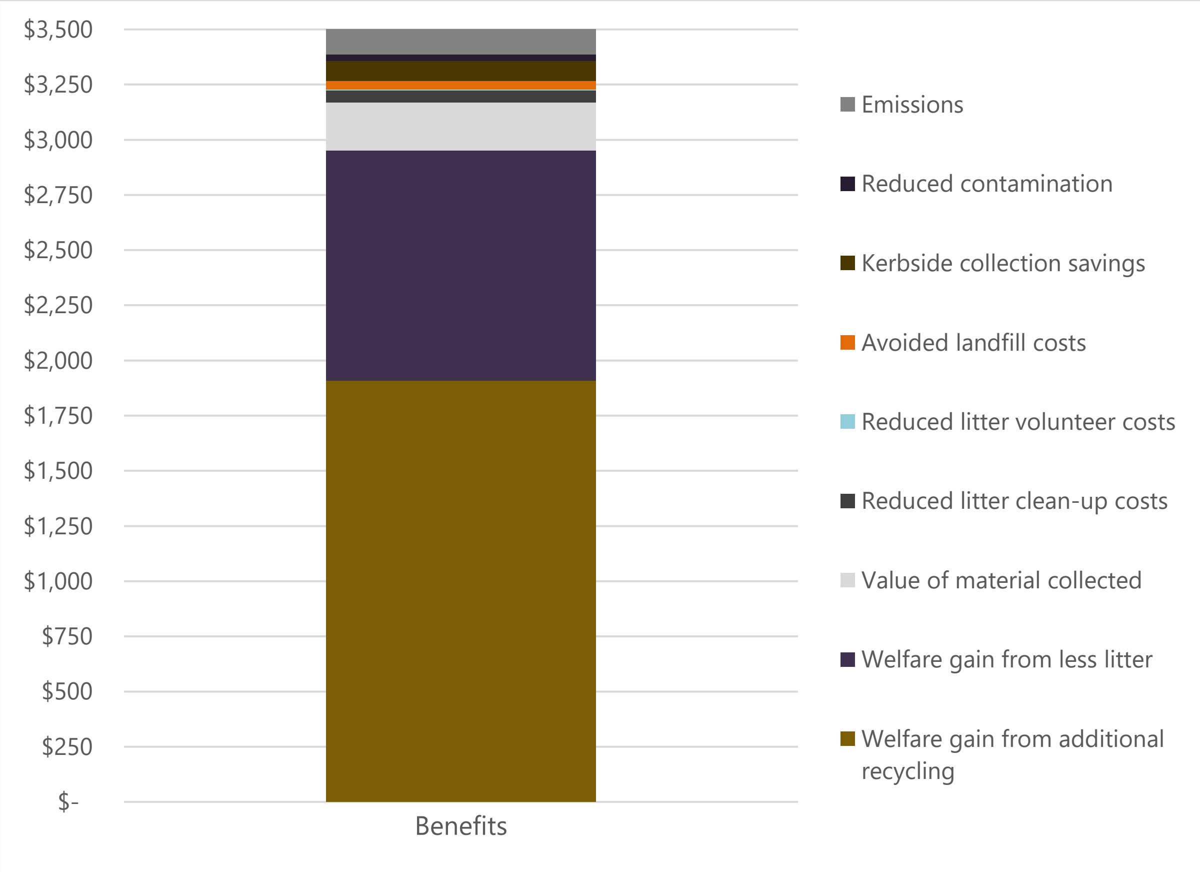
Table 27: Summary CBA results (PV, $m)

Category	Value
Total benefits ($m, PV)	$3,524 ($1,515 to $4,981)
Total costs ($m, PV)	$2,389
Net benefits ($m, PV)	$1,135 (-$874 to $2,592)
Benefit-cost ratio	1.47 (0.63 to 2.08)

Gains in welfare responsible for 84 per cent of total benefits

Figure 2 shows that the major benefit category is the welfare gain to households from an increase in recycling following the introduction of the CRS. On its own, this benefit category accounts for about 54 per cent of the total estimated benefits. When combined with the welfare gain to households from litter reduction, the welfare gains account for 84 per cent of total benefits. Given the magnitude of this impact, a range of sensitivity analysis (Benefits reduce if item count used as litter metric) has been conducted and ranges are reported in brackets to indicate the uncertainty around these calculations.

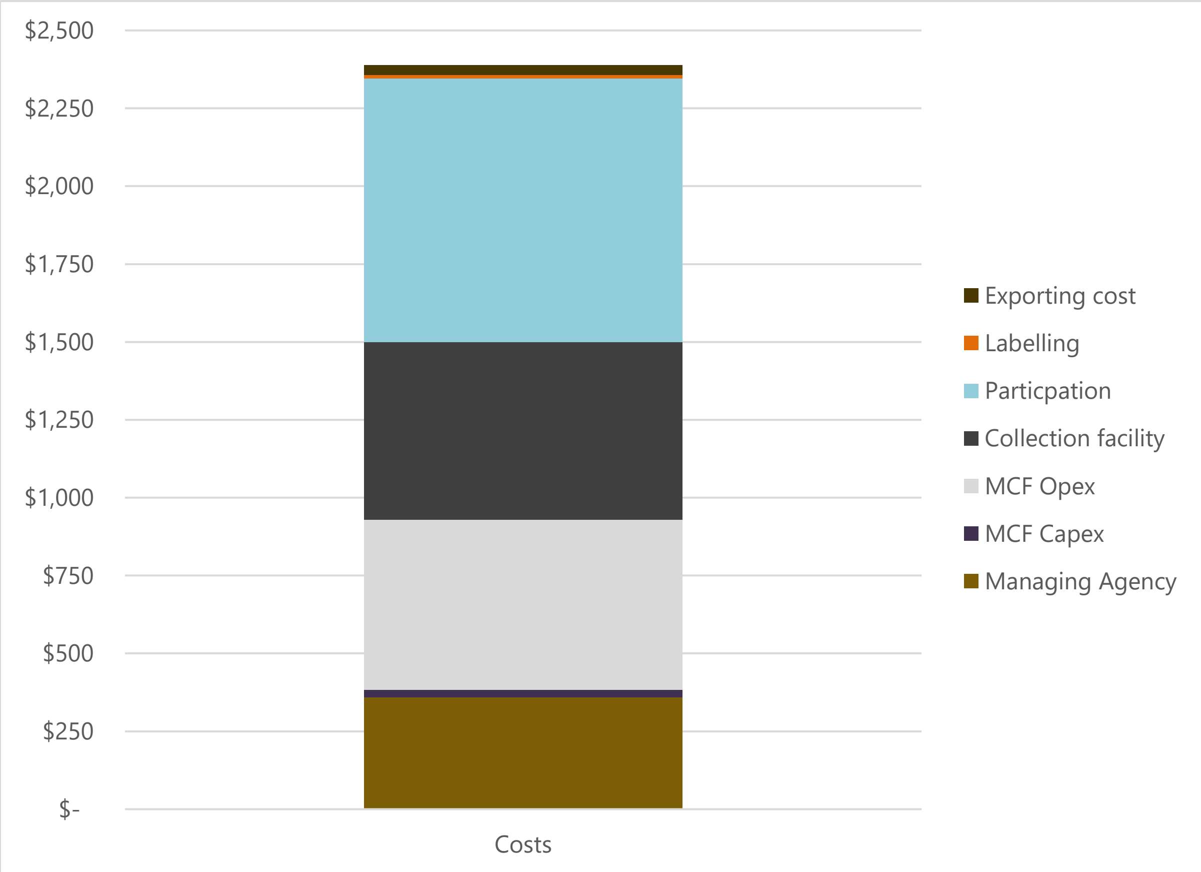
Figure 2: Composition of benefits (PV, $m)



Total costs are dominated by MCF and Return Facility costs

Figure 3 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 return depots (around 47 per cent of total costs). Household participation costs represent around 36 per cent of total cost.

Figure 3: Composition of costs (PV, $m)



Basic results mainly robust to sensitivity analysis

We subjected the results above to changes in some key assumptions. 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 in 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 that continue to accrue across time. Thus, any differential that might be brought about through the effect of timing and discounting is effectively nullified.

Table 28: Benefit-cost ratios for alternative time periods

Period	BCR
10 years	1.31
20 years	1.43
30 years	1.47
40 years	1.49
50 years	1.51

Table 29: Benefit-cost ratios for alternative discount rates

Discount rate	BCR
2%	1.52
4%	1.49
5%	1.47
6%	1.46
8%	1.43

Benefits reduce if item count used as litter metric

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 30, showing that if item count is used with only the CIE (2022) method, then the BCR dips to 1.09. If either weight or volume is used as the metric to measure litter, the BCR increases. The Cherchi et al. (2020) study estimates a value for a percentage change in container litter so does not vary based on the total litter estimate. Our preferred average measure represents a practical middle ground.

Table 30: Willingness to pay litter reduction benefit with different metrics and studies

Litter metric	(PwC, 2010)		(Cherchi, et al., 2020)		(CIE, 2022)		Average	
	30 year PV $m	BCR	30 year PV $m	BCR	30 year PV $m	BCR	30 year PV $m	BCR
Average	$1,593	1.71	$1,203	1.54	$328	1.18	$3,524	1.47
Item	$589	1.29	$1,203	1.54	$121	1.09	$3,120	1.31

Weight	$2,452	2.07	$1,203	1.54	$505	1.25	$3,869	1.62
Volume	$1,739	1.77	$1,203	1.54	$358	1.19	$3,582	1.50

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 places more emphasis on larger bulky containers.

Table 31: KNZB litter audit results

	Item count	**Weight**	**Average volume**	**Average**
Percentage litter	9%	36%	26%	24%

Source: KNZB litter audit 2019

Table 32: 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%

These values are relatively consistent with Australian evidence of achieved/reported beverage litter reduction, see Appendix A for comparison to SA and phase-in rates.

Stadium effect from litter reduction increases BCR

Another 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".[21] The results are presented below in Table 33.

PwC (2010) finds a linear treatment over the tested levels of litter reduction is a construct of the model but is found to be an acceptable approximation of the true relationship as alternative, non-linear functional forms did not produce a better fitting model. Therefore the 30 per cent litter reduction using the PwC (2010) study results in households' willingness to pay $140 per year for the litter reduction.

Cherchi et al. (2020) report a value reduction for beverage container litter reduction, but using another method also find a mean reduction for total litter of less than 40 per cent to be £0.66 and £0.49 for litter reduction above 40 per cent, showing diminishing marginal benefit for reducing litter overall. We use this to construct a total litter reduction value in NZ dollar terms of $33 for 30 per cent reduction and $63 for a 64 per cent reduction. While this is a result of the study design and implementation, it may indicate that beverage litter reduction is valued higher than other types of litter.

For the Centre for International Economics (2022), we assume linearity to find values of $29 for a 30 per cent reduction in total litter and $61 for a 64 per cent reduction.

Table 33: CRS induced total litter reduction

Total litter reduction	PwC (2010)		Cherchi et al. (2020)		CIE (2022)		Average	
	30 year PV $m	BCR	30 year PV $m	BCR	30 year PV $m	BCR	30 year PV $m	BCR
30%	3,307	2.42	775	1.36	681	1.32	1,588	1.70
47%	5,181	3.21	1,728	1.54	1,067	1.49	2,484	2.08
64%	7,055	3.99	1,493	1.66	1,453	1.65	3,334	2.43

Confidence intervals for litter WtP studies

Adjusting for confidence intervals extracted from studies used for recycling and litter WtP does not produce any surprises.

[21] 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).

Table 34: Confidence intervals for WtP studies

Study	Low	Core	High	BCR		
Litter				Low	Core	High
PwC (2010)	$1,152	$1,593	$2,304	1.52	1.71	2.00
Cherchi (2020)	$890	$1,203	$2,360	1.41	1.54	2.03
CIE (2022)	$192	$328	$519	1.12	1.18	1.26
Average litter	**$745**	**$1,042**	**$1,727**	**1.35**	**1.47**	**1.76**
Recycling						
PwC (2010)	$2,746	$3,205	$4,721	1.83	2.02	2.65
Covec (2007)	$159	$614	$1,388	0.74	0.93	1.26
Average recycling	$1,453	$1,910	$3,054	1.28	1.47	1.95
Total combined	**$2,197**	**$2,951**	**$4,782**	**1.16**	**1.47**	**2.24**

CIE study value for sites with litter and litter composition

The Centre for International Economics (2022) study raised questions about additionality between the number of sites with noticeable litter and the total reduction in litter. While we expect some additionality between total litter and the number of sites with litter, we did not include this in the core model as it increases uncertainty.

The study also investigated changes in the composition of litter. The analysis is interesting, but the application here is much more speculative. With 50 to 100 per cent additionality, the 30-year present value looks like much less of an outlier when compared to the other studies used.

Table 35: Litter sites and composition additionality

Element	Value $ per HH	30 year PV ($m)	50% additionality	100% additionality
Litter reduction	$14	$328		
Reduction in sites with litter	$24	$609	$633	$937
Change in composition of litter	$29	$761	$1,013	$1,698

Choosing only lower recycling willingness to pay study push BCR below 1

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 could 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 36 shows that only using the Covec (2007) study, which excludes metal, pushes the BCR below breakeven.

Table 36: Recycling willingness to pay (30 year PV $m)

Study	Recycling WtP benefits	Total benefits	BCR
PwC (2010)	$3,205	$4,819	2.02
Covec (2007)	$614	$2,228	0.93
Average	$1,910	$3,524	1.47

Accounting for optimism bias, the BCR falls below 1 with 40 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 37 shows it takes almost a 40 per cent reduction in willingness to pay benefits to result in net social costs.

Table 37: Optimism bias applied to willingness-to-pay benefits measures ($m, 30y PV)

Optimism bias	0%	10%	20%	30%	40%	50%
Recycling	1,910	1,719	1,528	1,337	1,146	955
Litter	1,042	937	833	729	625	521
BCR	1.47	1.35	1.23	1.10	0.98	0.86

BCR positive up to 50 per cent increase in key costs

Costs are often more than assumed so we show the level of extra cost required to result in a net cost to society. One of the key assumptions is the value of time, we have consistently used a figure of around $10 an hour so if we double it to align with the minimum wage then these costs also double.

Table 38: Increased costs impact

Optimism bias	0%	10%	20%	30%	40%	50%	Higher value of time
Product Stewardship Organisation	360	396	432	468	504	540	360
MCF Capex	23	25	28	30	32	35	23
MCF Opex	546	601	655	710	765	819	546
Depots	571	628	685	742	799	856	571
Participation	847	932	1,017	1,102	1,186	1,271	1,480
BCR	1.47	1.34	1.23	1.14	1.06	0.99	1.17

Glass-out scenario

The relativity between the benefits and costs for the respective glass-in, glass-out scenarios highlight the predominance glass containers have concerning gains in welfare from reduced litter and additional recycling.

Table 39: Comparison of result for a CRS excluding glass (30 year PV)

	Glass-in scenario	Glass-out scenario
Total benefits	$3,524 ($1,515 to $4,981)	$1,660 ($692 to $2,330)
Total costs	$2,389	$1,515
Net benefits	$1,135 (-$874 to $2,592)	$145 (-$824 to $815)
Benefit-cost ratio	1.47 (0.63 to 2.08)	1.10 (0.46 to 1.54)

For the glass-out scenario RVM costs are scaled by a factor of 0.54 to reflect reduced volume and weight, and for Product Stewardship Organisation, MCF CAPEX return depot costs scaled by 0.8.

BCR robust to adjusted 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, which impacts diversion from kerbside collections and unknown material flows and the expected rate of litter reduction. The rationale behind this change is that the deposit level acts as a participation incentive so adjustments will impact participation costs and diversion (from unknown flows and kerbside refuse and recycling collections) rates.[22]

The 80 per cent core assumption for participation is based on Canadian redemption rates. In this analysis, we adjust the final participation down to 68 per cent for a lower deposit level, and up to 91 per cent for the higher deposit, which adjusts household participation costs, the assumed litter reduction and increased recycling benefits as it reduces the expected diversion from kerbside collection and unknown flows.

The largest changes to benefits come from litter and recycling. There are also minor changes associated with volume-based benefits such as material value.

Table 40: Benefits with change in deposit level ($m 30 year PV)

Benefit category	Lower deposit (10c)	Core assumptions (20c)	Higher deposit (30c)
Welfare gain from increased recycling	1,632	1,910	2,161
Welfare gain from reduced litter	814	1,042	1,429
Value of additional material recovery	189	216	241
Litter clean-up costs	57	57	57
Litter volunteers	4	4	4
Avoided landfill costs	32	38	43
Kerbside collection savings	79	91	102
Reduced contamination of recycling	29	30	32
Emissions	117	137	154
Total benefits	**2,953**	**3,524**	**4,223**

The largest change to costs come from participation costs. There are also minor changes to costs associated with throughput (volume-based costs).

[22] 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.

Table 41: Costs with change in deposit levels ($m 30 year PV)

Cost categories	Lower deposit (10c)	Core assumptions (20c)	Higher deposit (30c)
Product Stewardship Organisation	360	360	360
MCF capital costs	23	23	23
MCF operating costs	475	546	612
Return facility costs	555	571	585
Participation costs	724	847	961
Labelling costs	10	10	10
Exporting cost	27	32	36
Total costs	**2,174**	**2,389**	**2,586**

For the 10 cents deposit level we assume beverage 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. Meaning a 12 per cent reduction in participation rates decreases the BCR to 1.36 with a modelled recovery rate of 83 per cent.

For a 30 cents 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. Along with 11 per cent higher participation rates this raises the BCR to 1.63.

Table 42: Summary deposit level sensitivity analysis ($ millions)

Steady state participation	Deposit level	Total benefits	Total costs	NPV (30 year)	BCR	Recovery rate
68%	10 cents	2,953	2,174	779	1.36	83%
80%	20 cents	3,524	2,389	1,135	1.47	90%
91%	30 cents	4,223	2,586	1,637	1.63	96%

Adjusting diversion from kerbside collections

We use the participation rate to assume diversion for kerbside. We test this assumption as there is Australian experience with lower diversion from kerbside. We lower the kerbside diversion rate by 50 per cent, changing the assumption to around 40 per cent of households participating. This reduces WtP for recycling to $903 million, and total benefits to $2.4 billion participation costs drop to $427 million, along with operating costs for total costs under $1.7 billion, resulting in a similar BCR of 1.46.

Adjusting demand response has little bearing on core parameters

We assume a 6.5 per cent decrease in consumption based on Australian evidence and PwC modelling. Testing this response has a minor impact on the core modelling.

Table 43: Adjusting demand response

Demand response	Total benefits	Total costs	NPV (30 year)	BCR
3.25%	3,545	2,430	1,115	1.46
6.5%	3,524	2,389	1,135	1.47
13%	3,482	2,306	1,176	1.51

Consumer welfare loss from reduced consumption possibly more than cancelled out by public health benefits

It is assumed for modelling tractability and lack of evidence that the volume of containers sold will drop by the same amount experienced in Queensland, Australia. There is considerable uncertainty around this figure due to inter alia the number of product iterations, sizes, types, and bundling options that all have independent price elasticities, and potential offsetting public health benefits from reduced consumption.

We did not include a consumer surplus loss in the core model or the potential offsetting impacts. However, we can provide a rough estimate as we know the assumed change in quantity of containers sold (6.5 per cent reduction) and can model the increase in price, the deposit level of 20 cents plus scheme fees of 4-5 cents a container (including GST).

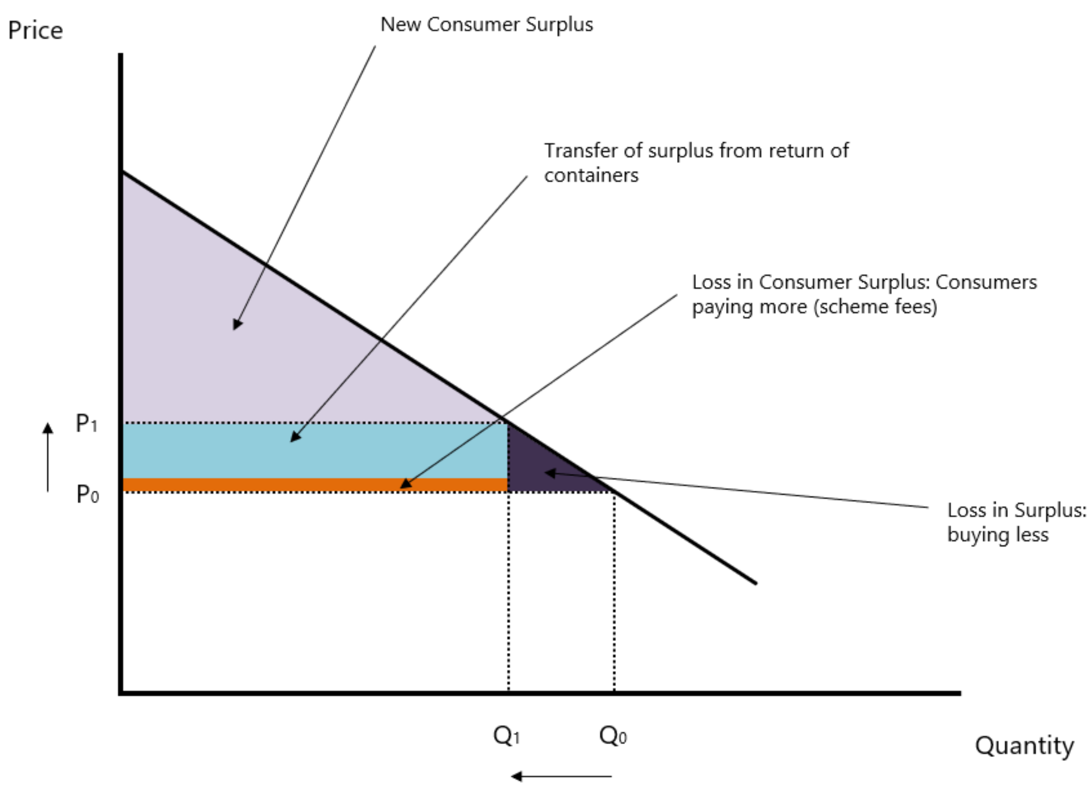
A simple calculation on the almost 2.5 billion assumed to be sold in year 1 of the scheme for the 6.5 per cent reduction equates to around 160 million fewer containers entering the market. The lost triangle of consumer surplus would then be around $20 million per year, with about 53 per cent of the container volume estimated to be from non-alcoholic beverages ($10.6 million).

The 20 cents deposit is considered a transfer as we have accounted for the participation time costs involved in getting the refund, so while this loss occurs at the point of sale, it can be recovered at the point of return.

The scheme fees of 5 cents are accounted for in the economic costs of the Product Stewardship Organisation, MCFs and return depots. However, there is also a consumer welfare loss: the 160 million containers times the 5 cents price increase results in a consumer surplus loss of around $115 million.

The elasticity of demand will affect the size of the demand response (changing the slope of demand curve), but this will just increase the size of the purple triangle ($20 million) and reduce the size of the orange rectangle ($115 million) in stylised Figure 4 below.

Figure 4: Consumer surplus theory



Offsetting public health benefit

A reduction in alcohol and sugary beverages likely has a variety of public health benefits. There are estimates of the harm and costs associated with alcohol consumption, obesity and diabetes that are linked to high consumption of sugary beverages.

Estimates of the direct costs of obesity to New Zealand are around $2 billion a year, with the total cost estimated to likely be in the range of $7 billion to $9 billion.[23] Diabetes is estimated to cost around $2 billion a year,[24] and alcohol misuse is estimated to cost New Zealand society around $8 billion a year.[25] The New Zealand Dental Association (NZDA) estimated it costs more than $20 million a year to anaesthetise children so they can undergo multiple tooth extractions as a consequence of consuming sugary drinks.[26]

Phonsukl et al. (2021) find a 1.73 per cent reduction in obesity associated with a 11 per cent tax. Based on the Household Economic Survey and Food Price Index, we crudely estimate a cost increase on non-alcoholic beverages of around 20 per cent. While attribution is highly uncertain and applies to a different context, it seems reasonable given the uncertainty to look at a 1 per cent reduction in direct

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[23] See The cost of excess weight in NZ
[24] See Cost of type 2 diabetes trajectory is staggering but fixable
[25] See Cost of alcohol to society
[26] See NZ Herald

costs of obesity cancelling out the consumer welfare loss triangle ($20 million) the assumption needs to be around 1.3% on total cost of obesity to offset the $115 million rectangle.

Based on these very high-level estimates there could be a net benefit from reduced consumption of alcohol and sugar.

Containers per tonne adjustment

Adjusting the assumptions around containers per tonne is warranted as the average weight of containers has been reducing. However, even allowing for very large changes has a small impact on the model. The changes largely offset household participation and manual return depot costs with recycling benefits as these are determined by the number/weight of containers.

Table 44: Containers per tonne conversions (000's)

Material type	50% more	PwC 2021	50% less
HDPE	22.545	15.030	7.515
PET	27.119	18.080	9.040
LPB	31.379	20.919	10.460
Metal (aluminium)	78.806	52.537	26.269
Glass	5.885	3.923	1.962
BCR	**1.28**	**1.47**	**1.63**

Source: PwC (2022)

Further peer review of methodology led to improved results

Sense Partners (Sense) reviewed the CBA update and an accompanying spreadsheet that details the calculations and assumptions. The review was of the methodologies used in the CBA, focussing on:

- sources of large costs and benefits
- updates to a version of the CBA that was published in March 2022 as part of a Ministry for the Environment's consultation on Transforming recycling.

The Sense review can be summarised as follows (see appendix for full review):

- For the benefit of readers and better reflect uncertainty, CBA results should be presented as ranges rather than mid-points
- Re-examination of studies used as inputs to the CBA would result in more defensible results

- More complete reasoning and explanation of some key parameters would assist in raising the confidence level that could be applied to the CBA results
- Some of the benefit calculations were erroneous.

We respond briefly below.

Litter reduction estimates not reasonable

The peer review concluded that the estimated reduction in container litter (-61%) is not reasonable based on the method for calculating this value being arbitrary and giving undue weight to very old observations of questionable provenance.

The statement, "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", was found to be misleading as the 61 per cent figure was not simply an average of overseas evidence, rather a weighted average of five overseas observations.

We used the average of Australian and United States evidence, finding the average of Australian experience to be a 46 per cent reduction and United States 77 per cent reduction for an average of 61 per cent. Sense points out this approach applies weights the individual observations, implying judgement was applied without sufficient explanation or justification.

While we acknowledge that the process to determine the relevant figure used (61 per cent) was not fully transparent, we do not agree that this renders the estimate as faulty or unreasonable. In updating the CBA, we scanned for updated evidence and found a range of figures that would increase the Australian average to 51 per cent. Including the lower of the range reported for the United States we get an average of 71 per cent. The average of these two figures is still 61 per cent. We also found some Canadian evidence that point to litter reduction of about 60 per cent (See 1.1.1.1.1.1.1.1Appendix AAppendix A for details). In conclusion, we have not adjusted the figure used as a result of the peer review comments.

We agree that the available studies appear to be based solely on litter audits pre and post introduction of a CRS, resulting in a less precise estimate of CRS effects. Direct attribution is challenging, and litter reduction measurement can be based on volume, item number or weight, meaning that the true effects could be lower or higher than the assumptions used. As a means of acknowledging the parlous state of available evidence, we extensively examine the litter reduction benefits in sensitivity testing.

CIE estimates of litter reduction benefits considered the most reliable

Sense questions why the three studies are equally weighted. In their view, a particular Australian study (from CIE) is the most reliable. Sense considers studies from England to be less relevant than Australian equivalents, given the close cultural and geographic similarity between New Zealand and Australia.

While that argument is not without merit, our view is that the available evidence base is not of sufficient volume or quality to allow us to conclude definitively that one study is most representative of the situation likely to prevail in New Zealand. We did not find evidence to suggest New Zealand attitudes towards litter are closer to Australian than English attitudes, so take the position that prioritising any study over others would risk spurious accuracy and ergo not necessarily strengthen the results.

Accurate and consistent conversion to New Zealand dollar values

Sense recommended using a single harmonized source of data for household incomes, such as the OECD income distribution database to ensure a consistent basis for converting the willingness-to-pay values to the New Zealand context. We have followed this advice, with a relatively modest effect of reducing the ratio of benefits to costs from 1.48 to 1.47.

More explanation and detailed reasoning would be very valuable

Sense suggested that the CBA would benefit from setting out, up front, a summary of the scale of the problem, how the CRS would work, and the framework of expected effects that generate costs and benefits. This would then put the remainder of the document into context.

In our view, this comment is more presentational than analytical in nature. Sufficient context is provided in this document and the other documents that this study updates, particular the foundation report in 2017.

We have however, responded to instances where more explanation about the judgements and reasoning underpinning the estimated impacts or exclusion of some costs and benefits was thought beneficial:

- Does not explain why carbon reductions will be achieved/additional.

  The carbon accounting is high level and indicative. There is a change in landfill-based emissions from the diversion of LPB material and a modelled reduction in emissions resulting from increasing material recovery assuming this equates to a reduction/offset of virgin material inputs.
- Benefit estimates due to reduced litter and from increased recycling are not based on a stated conceptual framework, and risks double-counting benefits from a perceived relationship between increased recycling and less litter.

  We consider increased recycling benefits to be in addition 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).[27]
- Does not estimate costs to producers whose profits are impacted by reduced sales of beverages. There may be good reasons for excluding this cost, but the exclusion is not explained.

[27] Further explanation of this approach and reference to a supporting study is contained in the 2017 foundation report.

We explore a loss of surplus fully weighted on the consumer to align with the assumption of full cost pass through and look the various offsetting effects. The array of potential elasticities and cross elasticities needed to get an accurate estimation of possible impacts on profit (a proxy for producer surplus) is missing, meaning attempts to quantify would effectively be guesswork. Further, the complex nature of pricing, bundling and container sizes associated with beverages adds to the quantification difficulties within the scope of this undertaking.

- Does not present, as part of the summary results, ranges for estimated scheme costs, only for the benefits. This asymmetry is curious and is not explained.

  We have more confidence in the estimates of scheme costs than we do of the willingness to pay estimates so feel the escalation of scheme costs is explored appropriately in sensitivity testing.

- Does not include estimates of consumer welfare costs, ostensibly on the grounds that those costs will be offset by health-related benefits. However, the potential scale of those offsetting effects is not explored in any detail, only with high level reference to aggregate costs of obesity, diabetes and alcohol use (without references).

  Due to variety of challenges including lack of knowledge on elasticities and cross elasticities we illustrate that there are likely offsetting public health benefits. We have added some references to the estimated health related costs used in this high-level exercise.

- Does not explain the choice of rates for phasing in the CRS effects.

  Originally the phase rate in was aligned with PwC financial modelling. We continue to use the PwC phase in of recovery rates for the participation rate. The litter impacts are simply a 50 per cent reduction in year one and full impact in year six. In effect, this approach is pragmatic in nature given available evidence, rather than a detailed investigation. In the absence of evidence in support of an alternative approach, we feel our approach is defensible.

In summary, where the peer review identified obvious errors or omissions, we corrected those and added additional material. Where the peer review related more to presentational, or assumption-based aspects, we provided further justification for our approach without necessarily re-litigating the overall approach. We found the peer review to be well thought-out and very helpful to the improvement of the report and resulting findings.

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Appendix A: Australian litter rates

Table 45: Australian beverage container litter rate

State	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19
SA	2.7%	2.2%	1.9%	2.2%	2.1%	1.9%	2.0%	2.9%	3.0%	2.8%	2.9%
QLD	5.3%	4.2%	5.0%	4.7%	4.8%	5.8%	5.5%	5.7%	6.6%	6.2%	4.0%
NT	3.2%	4.3%	5.3%	4.1%	2.1%	2.1%	2.0%	2.8%	2.6%	2.8%	4.9%
VIC	4.3%	7.1%	6.9%	7.0%	7.8%	8.1%	7.1%	7.4%	7.5%	6.5%	6.1%
NSW	6.1%	7.1%	6.9%	7.5%	8.0%	8.5%	8.7%	8.7%	9.6%	8.2%	6.6%

Source: https://www.epa.sa.gov.au/environmental_info/waste_recycling/container_deposit

Shaded in grey is the year of CRS implementation, note the South Australian scheme has been running for over 40 years.

Queensland implemented a scheme in 2017 and saw a 35 per cent drop in beverage container litter the year after. New South Wales reduction was around 20 per cent while the Northern Territory saw a reduction of 49 percent. An average year one reduction of 35 per cent.

We compare these rates to the South Australian rate as a test once fully implemented to show beverage litter rate on average in states without a CRS were 58 per cent higher.

Table 46: Comparison to SA litter rates

State	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	2017–18	2018–19
SA											
QLD	49%	48%	62%	53%	56%	67%	64%	49%	55%	55%	28%
NT	16%	49%	64%	46%	0%	10%	0%	-4%	-15%	0%	41%
VIC	37%	69%	72%	69%	73%	77%	72%	61%	60%	57%	52%
NSW	56%	69%	72%	71%	74%	78%	77%	67%	69%	66%	56%

The NSW EPA and National Litter Index report that rates of littering of Container Deposit eligible containers have reduced since the scheme commencement by 44 per cent.[28]

Studying the effectiveness of Container deposit legislation (CDL) at reducing the amount of beverage container litter on the coasts of two countries, Australia and the United States, found the proportion of containers found in coastal debris surveys in states with CDL was approximately 40 per cent lower than in states without CDL (Hardesty, Lawson, Opie, Wilcox, & Schuyler, 2018).

Table 47: Beverage Container Litter Reduction

Country	State	low	high
United States[29, 30]	Hawaii	38%	53%
	Iowa	76%	76%
	Maine	69%	77%
	Michigan	84%	84%
	New York	70%	80%
	Oregon	83%	83%
	Vermont	76%	76%
	Average U.S.	**71%**	**76%**
Australia[31, 32]	Northern Territory	46%	46%
	Queensland	35%	54%
	New South Wales	52%	57%
	Average Australia	**44%**	**52%**
Average of all observations		63%	69%

[28] https://assets.nationbuilder.com/boomerangalliance/pages/3831/attachments/original/1557107602/Boomerang_Report_dec_2018-final2_small.pdf?1557107602
[29] https://www.bottlebill.org/index.php/benefits-of-bottle-bills/litter-studies-in-bottle-bill-states
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[32] https://www.boomerangalliance.org.au/cash_for_containers

Average of U.S and Australian (50/50 weighting)	**58%**	**64%**

Table 48: Canadian litter reduction example

City	Percentage Change Since Baseline 2011 – 2017
Winnipeg	74.4%
Brandon	86.8%
Stienbach	69.2%
Flin flon	31.6%
Thomspon	36.4%
Average	59.7%

Source: https://www.gov.mb.ca/sd/wastewise/pdf/plans/cbcra_plan.pdf

Appendix B Peer review

SENSE PARTNERS
UNCOMMON KNOWLEDGE

21 November 2022

Cost-benefit analysis of a New Zealand container return scheme: review of methodology

1.1. Scope

We have reviewed a cost benefit analysis (CBA) of "A Container Return System for New Zealand: Cost-benefit analysis update" (Sapere, 17 November 2022) and an accompanying spreadsheet that details the calculations and assumptions in the CBA.

Our review is of the methodologies used in the CBA, focussing on:

- sources of large costs and benefits
- updates to a version of the CBA that was published in March 2022[1] as part of a Ministry for the Environment's consultation on Transforming recycling.[2]

1.2. Summary assessment

In this summary section we present key messages from our review. In the next section we step through more detailed commentary and recommendations for improving the CBA.

1.2.1. Users of the CBA should reflect upon the ranges, not mid-points

In our opinion the methods used in the CBA are reasonable under the circumstances but, given the extent of uncertainty, the CBA results should be considered indicative, with the full range of results and qualitative discussion used to inform any decisions about the scheme, rather than rely on mid-point estimates.

This is because the circumstances under which the CBA is conducted are not ideal:

- there is limited New Zealand specific information on key aspects of the Container Return Scheme (CRS) such as:
    - end-of-life destinations of containers, currently, with 42% of containers purchased having unknown destination
    - the scale of social costs to be addressed by the scheme e.g. the amount of containers that end up as litter
    - New Zealanders' willingness to pay to increase the number of containers recycled

[1] https://environment.govt.nz/assets/publications/A-container-return-system-for-New-Zealand-cost-benefit-analysis-update.pdf
[2] https://environment.govt.nz/publications/transforming-recycling-consultation-document/

- the effects of the CRS on littering and recycling and on social welfare are highly uncertain. There are a range of effect sizes observed overseas and these observations vary widely because of:
    - differences in CRS scheme design, such as the size of refunds for container return
    - social and cultural context, including some studies being very old and some much more recent
    - research methodologies, which in many cases are unknown and.

We note that the CBA does not include analysis of alternative options or scheme designs. This limits the usefulness of the CBA as a decision-making aid.

1.2.2. The CBA would be much improved if other studies and observations were regarded with a more critical eye

The CBA makes extensive use of overseas observations (so-called benefit transfer) to estimate the potential effects of a CRS in New Zealand. However, these overseas observations do not appear to have been sufficiently scrutinised to give the reader confidence about their applicability.

For example, some of the overseas observations about CRS-related reductions in litter have highly questionable provenance or applicability to a New Zealand CRS, yet are given high weight in the calculations of benefits of a CRS in New Zealand.

1.2.3. Confidence in the CBA results would be much improved with more complete reasoning or explanation

The CBA fails to explain the frameworks used or, in several cases, judgements made in the course of constructing the CBA. More explanation would be very valuable and would improve confidence in the overall results.

1.2.4. Some of the calculations of benefits need revisiting

Our review of the calculations in the CBA spreadsheets suggest inconsistencies in the calculation of per household benefits from increased recycling and reduced litter. Some of the estimated benefits are too low and others are too high.

1.3. Detailed feedback

1.3.1. Litter reduction estimates not reasonable

The estimated reduction in container litter (-61%) is not reasonable. The method for calculating this value is arbitrary and gives undue weight to very old observations of questionable provenance.

The 61% reduction in litter is explained as follows:

> "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" (p.30)

This statement is misleading as the 61% figure is not simply an average of overseas evidence. It is in fact a weighted average of a select[3] five overseas observations (note that the scheme descriptions that follow are examples and are not intended to be comprehensive):

- an estimated 84% reduction in litter in the US state of Michigan, given a weight of 25% in the calculated average
  - from a 1979 report on the effects of a CRS implemented in Michigan in 1976[4]
  - the Michigan scheme refunded US 10 cents per container, in 1976 dollars[5]
- a lower bound estimated 69% reduction in litter in the US state of Maine, given 25% weight in the calculated average
  - from a 1980 report by the US Government Accountability Office[6]
  - the Maine scheme was legislated in 1978
  - the scheme had variable refund rates, as determined by bottlers, though the range appears to be 5 cents to 20 cents in USD 1978 dollars
  - the report includes two different ranges for estimates of beverage container litter reduction, one of 69% to 77% and another of 55% to 56%.
- an estimate of 46% less container litter in Australia's Northern Territory, given a 16.7% weight in the average
  - scheme introduced in 2012
  - refund value of AUD 10 cents per container
- an estimate of 35% less container litter in Queensland, given a 16.7% weight in the calculation

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[3] The calculation Sapere uses ostensibly involves taking an average of high and low estimates for litter reduction in US states, from available observations. The range is taken to be 69%-84%. Yet this is not the range of observations. Rather it is the range of observations after excluding results for Hawaii for 2007 that show a reduction of 38%-53% on the grounds that it is an outlier – according to the site that reports these numbers. There is no explanation as to why the Hawaiian observation should be considered an outlier and notably, the Hawaiian observation is the most recent by two decades. Disregarding the Hawaiian observation without any meaningful justification is unreasonable. Simply saying outlier is not sufficient justification.

[4] We have not been able to find a copy of this report, cited on a website promoting container refund legislation https://www.bottlebill.org/index.php/benefits-of-bottle-bills/litter-studies-in-bottle-bill-states.

[5] Notably US average wages have increased 6-fold since 1976, indicating that a comparable contemporary refund rate, in terms of incentive effect, would be around USD 60 cents in 1976 dollars. In 2021 dollars this equates to $3 per container, with general consumer prices increasing 5-fold since 1976.

[6] https://www.gao.gov/assets/pad-81-08.pdf

    - scheme introduced in 2017
    - refund value of AUD 10 cents per container
- an estimate of 57% less container litter in New South Wales, given 16.7% weight in the calculation
    - scheme introduced in 2018
    - refund value of AUD 10 cents per container

The above studies appear to be based solely on litter audits pre and post introduction of a CRS. That being so they are not very precise estimates of effects. The true effects could be lower or higher.

We would have expected more scrutiny of these and other observations. Some are clearly more applicable to contemporary New Zealand, albeit that some judgement may be needed in determining whether the New Zealand scheme might have smaller or larger effects given its particular design (or indeed differences in pre-existing interventions, public practices, and attitudes to litter).

At a minimum, a naïve approach that does not make judgements about the applicability of different overseas observations to the New Zealand context should not exclude observations or give differential weight to the observations.

1.3.2. We are inclined to think that the CIE estimates of litter reduction benefits are the most reliable

The CBA's ranges for benefits from reduced litter use willingness-to-pay measures from three studies: two from Australia and one from England. A mid-point estimate for willingness-to-pay is constructed by averaging the three studies.

We have some sympathy for the simplicity of using a simple average to present a central estimate of willingness-to-pay to reduce (visible) litter.

However, the CBA acknowledges that the most recent Australian study is likely to be the most robust, methodologically, so we wonder why it is not given higher weight. In addition, the earlier Australian study is acknowledged to contain selection bias that increases estimated willingness-to-pay. So that study should be discounted. Furthermore, we consider the English study to be less relevant than Australian studies, given the closer cultural and geographic similarity between New Zealand and Australia than New Zealand and England.

The CBA report says:

> "While we could have restricted our estimation process by using a single study, such a process would require judgment on the relative merits of different studies, which we considered too risky to be of value." (p.v)

In our view that argument is quite weak, in particular given the acknowledged weaknesses and because there is no explanation about what the risks are that are considered to be too risky.

1.3.3. We are not sure the overseas willingness-to-pay values have been accurately and consistently converted to NZ dollar values

We found some inconsistent references to disposable income values in the spreadsheet model. This raised a question about whether willingness-to-pay values had been appropriately adjusted from overseas values to New Zealand values.

The adjustment of overseas values needs to take account of:

- differences in incomes
- differences in currencies (ideally purchasing power)
- differences in prices (inflation) between the years the estimates are from and the base year for the CBA (2021).

We suspect that there are problems with the income-conversions and part of the problem may be e.g. comparing medians to means or comparing equivalised (household size adjusted) incomes with unequivalised incomes.

We recommend using a single harmonized source of data for household incomes, such as the OECD income distribution database. This would ensure a consistent basis for converting the willingness-to-pay values to the New Zealand context.

We have constructed an example table which is provided with this memo.

1.3.4. More explanation and detailed reasoning would be very valuable

The CBA would benefit from setting out, up front, a summary of the scale of the problem, how the CRS would work, and the framework of expected effects that generate costs and benefits. This would then put the remainder of the document into context.

There are several instances where the CBA would be much more useful – more reliable – if there was more explanation about the judgements and reasoning applied in the construction of estimates or exclusion of some costs and benefits. For example, the CBA:

- estimates benefits of reduced greenhouse gasses (tonnes x a social cost of carbon) but does not explain why those reductions will be achieved/additional
- estimates benefits from reduced litter and from increased recycling and does not explain the conceptual framework that is used and whether there is any risk of double-counting benefits because of perceived relationships between increased recycling and less litter[7]

[7] To our minds these are conceptually separate effects but we would expect some explanation about why this can be considered to be the case and why the willingness-to-pay estimates adequately address potential for conflation of the separate effects.

- does not estimate costs to producers whose profits are impacted by reduced sales of beverages. There may be good reasons for excluding this cost, but the exclusion is not explained
- does not present, as part of the summary results, ranges for estimated scheme costs, only for the benefits. This asymmetry is curious and is not explained
- does not include estimates of consumer welfare costs, ostensibly on the grounds that those costs will be offset by health-related benefits. However, the potential scale of those offsetting effects is not explored in any detail, only with high level reference to aggregate costs of obesity, diabetes and alcohol use (without references)[8]
- does not explain the choice of rates for phasing in the CRS effects

1.3.5. We recommend the CBA spreadsheet model receives a tidy-up if the CBA is shared publicly

The CBA spreadsheet model is very messy and hard to follow. It would be well worthwhile devoting time and resource to cleaning up the file so it can be more easily understood. This is particularly important because the spreadsheet clarifies how the CBA works.

[8] We note that the CBA appears to refer to a study of the social costs of alcohol that has been discredited (https://www.nzae.org.nz/wp-content/uploads/2011/Session4/46_Crampton.pdf). We recommend reconsideration of the citation of this estimated cost. Also, the study citing effects of sugar taxes on obesity (Phonsuk, 2021) is not at all causal, but rather a modelling study which excludes substitution effects and is of no use in this context. We also suggest consideration of the economics literature on sugary beverage taxes eg Allcott, H., Lockwood, B.B., Taubinsky, D., 2019. Should We Tax Sugar-Sweetened Beverages? An Overview of Theory and Evidence. Journal of Economic Perspectives 33, 202–227. https://doi.org/10.1257/jep.33.3.202 That paper does lend support to a first-order assumption that health benefits will be sufficiently large as to offset consumer surplus losses.

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