State of Oregon
Department of
Environmental
DEQ Quality

Overview of Scenario Modeling:
Oregon Plastic Pollution and Recycling Modernization Act

Prepared for the Oregon Department of Environmental Quality

by Cascadia Consulting Group
with Bell & Associates and Circular Matters

March 14, 2023

CASCADIA CONSULTING GROUP
Bell & Associates
Circular Matters

Acknowledgments

DEQ LEADERSHIP

From February 2022 to February 2023, DEQ sponsored the development of this model to inform rulemaking associated with the implementation of the Recycling Modernization Act.

DEQ

DEQ Materials Management led the process, developed scenario concepts, provided baseline tonnage data on materials and dispositions, reviewed the consultant's model, and modeled indirect costs. DEQ also issued a request for information to gather data to inform modeling and qualitative scenario analysis.

David Allaway served as overall project manager for DEQ. Other agency contributors included Justin Gast, Martin Brown, Peter Spendelow, and Peter Canepa.

Recycling Lists Technical Workgroup

DEQ convened a technical workgroup that provided information and important feedback on evaluation methods, data sources, and preliminary research findings. The group met six times between March and September 2022, and all meetings were open to the public.

Workgroup members included representatives from Oregon cities and counties, waste collection companies, recycling processors and equipment suppliers, other recycling industry organizations, and DEQ's counterpart agency in Washington (Department of Ecology).

The complete Workgroup meeting materials and membership list can be found at www.oregon.gov/deq/recycling/Pages/Material-Lists.aspx

EXTERNAL CONSULTANT TEAM

Cascadia Consulting Group, Inc.

Jessica Branom-Zwick, Senior Associate, led Cascadia's work on this project, developing the model and working with stakeholders to refine the analyses. Jessica has 17 years of experience in evaluating, modeling, and analyzing waste and recycling programs using Cascadia's waste characterization data supplemented by external studies, evaluations, PRO annual reports, and other research. Cascadia has managed more than 500 waste characterization studies for more than 100 distinct clients from statewide to MRF-level to document material flows and program performance. Jessica was supported by analysts Carolina Paez Jimenez, Angela Pietschmann, and Kirstin Hervin and graphic designer Julie Stein.

Bell & Associates, Inc.

Chris Bell is a Certified Public Accountant, licensed in Oregon, practicing in integrated solid waste management with an emphasis on the financial analysis and operational evaluation of waste and recycling collection systems. He has 22 years of experience assisting public and private entities with setting collection rates, financial and performance audits, and facility and systems analysis. In 2022, he reviewed the financial results of 22 franchised collection companies, audited four companies, and set rates for nine jurisdictions in Oregon.

Circular Matters, LLC

Tim Buwalda, Principal at Circular Matters, has over 25 years of comprehensive recycling and solid waste management consulting experience, working extensively with companies and trade associations throughout North America. He has a diverse range of hands-on experience and knowledge in materials recovery facility design, financial analysis, policy analysis, recycling program evaluation and optimization, and development of recycling solutions for plastics and recovered paper.

The Why

Why DEQ commissioned this modeling and how it will be used

Why create this model?

OREGON'S RECYCLING MODERNIZATION ACT

Oregon's *Plastic Pollution and Recycling Modernization Act, SB 582 (the Act)* was adopted by Oregon's Legislature and signed into law by then Governor Kate Brown in 2021. The Act reforms Oregon's decades-old recycling policy with a series of new programs and requirements aimed at reducing environmental impacts, restoring public confidence, and creating recycling systems that are more equitable, responsible, resilient to future changes and aligned with Oregon's 2050 Vision for Materials Management. Central to the Act is a "shared responsibility model" that defines new responsibilities for state and local government, collection service providers, operators of facilities that process commingled recyclables, and producers.

SETTING STATEWIDE RECYCLING ACCEPTANCE LISTS

One element of the Act is a requirement that the State define two distinct statewide recycling acceptance lists:

- A list of materials that **regulated local governments** (generally speaking, cities with populations over 4,000 and the operators of disposal sites) **must collect** from the public for recycling. An important subset of that first list, called the Uniform Statewide Collection List, designates materials that may be commingled for collection.
- A separate, second, list identifying additional materials for which one or more **Producer Responsibility Organizations** (PROs) must provide recycling opportunities.

Both lists are initially to be established by Oregon's Environmental Quality Commission (EQC) through administrative rules.

The Recycling Modernization Act aims to make recycling services more responsive to current conditions and resilient to future challenges, reduce environmental impacts and other detrimental impacts to human well-being, and consider impacts across the full life cycle of materials.

Central to the Act is a "shared responsibility" model that obligates certain producers according to principles of extended producer responsibility. Equitable collection service, permitting of commingled processing facilities, and new standards for responsible end markets are among the other central features of the Act.

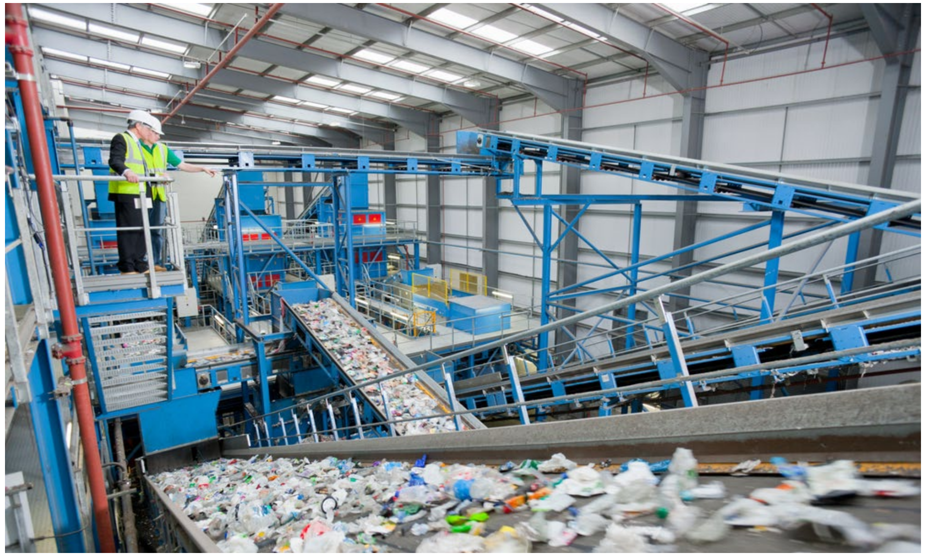
Why create this model? (Continued)

HOW THIS MODEL INFORMS RULEMAKING

The Act requires that the EQC, prior to designating materials to any acceptance lists, first consider a number of specific criteria that are defined in statute. While DEQ has conducted a separate analysis of most of these criteria, two criteria (“economic factors” and “environmental factors from a life cycle perspective”) required a different level of analysis. A third criterion (“anticipated yield loss for the material during the recycling process”) informs analysis of those economic and environmental considerations.

DEQ commissioned a team lead by Cascadia Consulting Group, Inc. (Cascadia) to develop a computational model of statewide waste generation and material flows for a variety of different policy and program scenarios. Cascadia’s model also evaluates direct (market) costs and commodity revenues associated with each scenario. Modeled material flows are then evaluated by DEQ for thirteen different types of projected environmental impacts, which are in turn evaluated for their potential cost or benefit to society. Costs related to environmental impacts are herein referred to as “indirect” costs.

Together, the evaluation of direct costs, indirect costs, and environmental impacts are intended to help satisfy the statutory evaluation requirement. More importantly, evaluation of economic and environmental impacts informs DEQ’s recommendations around the range of materials to be accepted for recycling as well as the methods of collecting and processing recyclables.



Economic and environmental considerations are only two of a dozen or so evaluation criteria, but they are important considerations.

Comparing costs and impacts across scenarios also helps to answer questions involving specific materials and program elements such as:

- Do depots or on-route collection offer greater net benefits?
- What are the costs to Oregon of recycling a specific material?

The cost of materials management in Oregon

DIRECT AND INDIRECT COSTS

Historically, analyses of the cost of managing materials has included only direct costs that are included in the market price of the good or service being sold or purchased. Oregon takes a broader view and considers the full cost of managing materials to include indirect costs – impacts to society and the environment that create financial harms or benefits elsewhere in the economy.

- **Direct costs** include spending by solid waste collectors and transporters; transfer stations and recycling depots, material recovery facilities (MRFs) and landfills, and government agencies that provide education, policy, or regulation on solid waste. Direct costs also include commodity revenues that MRFs receive for marketed materials.
- **Indirect costs** include a monetary estimate of the cost to society and the environment of impacts from the production, use, and end-of-life management of materials such as global warming, smog, acidification (acid rain) and toxicity to humans and animals. These indirect costs include impacts from climate change, loss of ecosystem services, and illnesses, disability and death (and associated health care costs). These economic consequences are just as real as those of direct costs but are typically excluded from transactional considerations such as purchases of fuel or capital.

  Extracting and producing new materials creates harmful impacts, and therefore **indirect costs**. By reducing the need for extraction and production, recycling – if done well – creates "savings" of negative indirect costs, in the same way the commodity revenues create savings with negative direct costs.
- **Net costs** are presented in this report, adding up both direct costs and indirect costs.

This report presents the estimated annual cost for a future year of full implementation. Costs are presented in 2021 dollars, not adjusting for future inflation.

For more information about the methodology see:
Appendix B. Tonnage and Direct Cost Methodology
Appendix C. Indirect Cost Methodology and Uncertainty

The cost of materials management in Oregon (continued)

TYPES OF DIRECT AND INDIRECT COSTS INCLUDED IN THE MODEL

Direct Costs

Recycling education

Included:
- Spending by solid waste collection companies.
- Spending by local governments.*

Not included:
- Spending by community organizations.

Collection and transfer/transport

Included:
- Spending by garbage and recycling collection companies, transfer stations, and other regulated facilities to collect materials from generators, consolidate them, and transfer them to a processing or disposal facility.
- Estimated cost to drive materials to PRO depots.

Not included:
- Estimated value of time for waste generators to sort recyclables.

Disposal and processing

Included:
- Spending by transfer stations and landfills (from tip fees).
- Spending by MRFs, based on estimated costs for capital equipment, labor, facility and operations, transfer to secondary MRF, and residual disposal.
- Revenues for marketed materials, based on estimated commodity values.

Not included:
- Spending to transport baled materials to the end-market

Indirect Costs

Environmental Impacts

Included:
- Global warming
- Ecotoxicity
- Smog
- Ozone depletion
- Water consumption
- Acidification
- Eutrophication

Not included:
- Impacts related to marine debris
- Impacts related to burning or other dumping of "leakage" from recycling

Impacts to Human Health and Systems**

Included:
- Toxicity that causes cancer and non-cancer harms
- Particulate air pollution

Not included:
- Impacts related to open burning
- Mental health
- Long-term system stability

* Local government spending on recycling education is primarily funded by local surcharges on garbage tip fees, which are included in the model.
** Some environmental impacts (above) also impact human health.

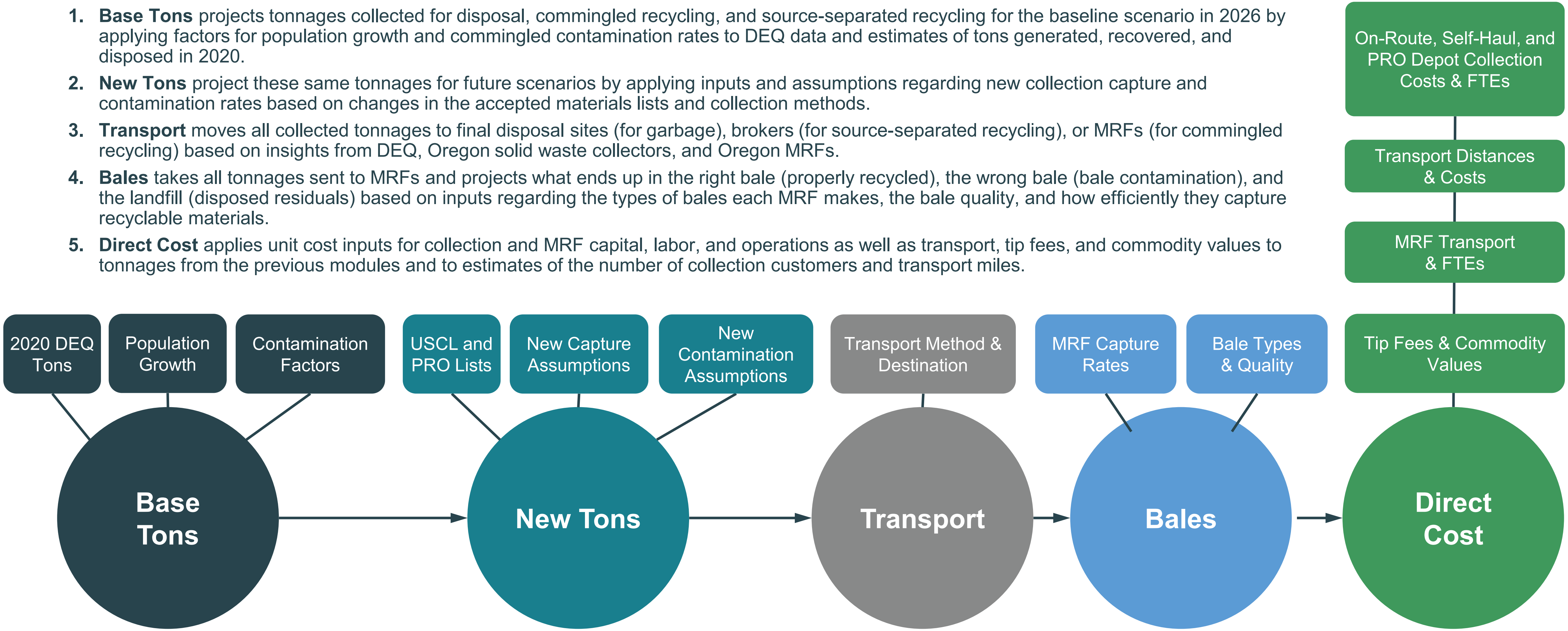
Model Overview

An overview of the tonnage, impact, and cost models

Tonnage and direct cost model

The tonnage and direct cost model was built in Excel with five sequential modules that project different parts of the solid waste system.

1. **Base Tons** projects tonnages collected for disposal, commingled recycling, and source-separated recycling for the baseline scenario in 2026 by applying factors for population growth and commingled contamination rates to DEQ data and estimates of tons generated, recovered, and disposed in 2020.
2. **New Tons** project these same tonnages for future scenarios by applying inputs and assumptions regarding new collection capture and contamination rates based on changes in the accepted materials lists and collection methods.
3. **Transport** moves all collected tonnages to final disposal sites (for garbage), brokers (for source-separated recycling), or MRFs (for commingled recycling) based on insights from DEQ, Oregon solid waste collectors, and Oregon MRFs.
4. **Bales** takes all tonnages sent to MRFs and projects what ends up in the right bale (properly recycled), the wrong bale (bale contamination), and the landfill (disposed residuals) based on inputs regarding the types of bales each MRF makes, the bale quality, and how efficiently they capture recyclable materials.
5. **Direct Cost** applies unit cost inputs for collection and MRF capital, labor, and operations as well as transport, tip fees, and commodity values to tonnages from the previous modules and to estimates of the number of collection customers and transport miles.



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Data sources for tonnage and direct cost modeling

BASELINE TONNAGE DATA

- Historic and baseline data on tonnages disposed and recovered by material type, generating sector, and geographic grouping from DEQ's waste characterization studies, DEQ's annual recovery reports, and the consultant's prior modeling for DEQ.
- Population data and projections for 2015-2025 from Portland State University.
- Baseline commingled recycling contamination from studies conducted in and for Metro on single-family (2015 and 2020), multifamily (2017), and commercial (2020) recycling.

SCENARIO COLLECTED TONNAGE INPUTS

- Current collection capture rates for materials accepted in Metro, or Oregon-specific collection capture rates for similar materials.
- On-route capture rates for commingled materials from the City of Seattle.
- Glass collection or capture rates for on-route and/or depot collection from Rogue Disposal and Recycling, and the cities of Beaverton, Hillsboro, and Tacoma (WA).
- Contamination reduction based on customer engagement research conducted in 2020 for Oregon's Recycling Steering Committee and additional data from consultant projects.

SCENARIO MRF PROCESSING TONNAGE INPUTS

- MRF capture rates and bale contamination rates were developed based on publicly available and confidential information from MRF operators in and outside Oregon, MRF equipment manufacturers, and consultant expertise from past MRF studies.

DIRECT COST DATA

On-route and solid waste depot collection costs **(see slide 14 for more details)**
Data from collectors and local governments in Oregon representing:

- **Group 1:** 222,208 residential and 4,974 commercial/multifamily customers.
- **Group 2:** 112,340 residential and 6,899 commercial/multifamily customers.
- **Group 3:** 3 counties and 1 coastal city with 27k RES and 923 COM/MF accounts.
- **Group 4:** Tillamook County excluding the City of Tillamook.
- **Depot recycling:** 41 depots around Oregon.

PRO depot costs:

- **Capital costs:** building lease rates researched by Metro and from Loopnet.com, industry costs for collection containers
- **Solid waste site improvements:** Lane County transfer stations
- **Labor costs:** OBRC job postings
- **Operating costs**: incentives paid by RecycleBC to PRO depot operators, plus cost estimates for aerosol draining from DeSpray Environmental and cost and operational inputs for EPS densification from Tillamook County and Intco Recycling (maker of GreenMax densifier equipment).
- **User driving:** DEQ survey of recycling specialists on user trips per year, surveys of more than 800 depot users at 19 depots, and IRS federal mileage rate

Transport costs: combination of actual haul costs from collectors plus rate quotes from trucking companies

Sortation costs: Based on publicly available and confidential information from MRF operators in and outside Oregon, equipment manufacturers, LeadPoint, and consultant expertise.

Commodity values: publicly available data, such as RecyclingMarkets.net

Environmental impacts and indirect costs

THE CONCEPT OF INDIRECT COSTS

Oregon's waste management system, like any system operating in the real world, has environmental and human consequences that are not reflected in traditional accounting statistics such as direct costs or revenues. For example, operating a diesel-powered recycling collection truck leads to several types of environmental impacts, including:

- Emissions of respiratory pollutants often known as "PM 2.5," elevated levels of which have been associated with increased asthma attacks, hospital visits, and reduced ability to work.
- Emissions of greenhouse gases, which contribute to climate change, with consequences that stretch over the entire world, including loss of agricultural productivity, need for new infrastructure, and higher prices for raw materials.

Such impacts are often expressed in technical terms, such as tons of pollutant. But these impacts have very real financial consequences for both individuals and societies. For example, individuals (or their insurance companies) have to pay for hospital visits; governments (or their taxpayers) have to pay for new infrastructure.

A calculation of "indirect costs" for a system is the sum of all the financial costs that can reasonably be connected with the system's environmental impacts. Indirect costs are expressed in dollars, and can thereby be compared to or combined with more traditional accounting statistics such as direct costs or revenues.

It is important to note that indirect costs need not represent a cost to society; indirect costs may also be negative and represent a benefit to society. While the recycling truck in the example above is emitting pollutants, the recycling it is enabling may prevent the need for manufacturing based on "virgin" raw materials from mines and forests. Since creating products with recycled feedstocks usually creates less pollution than creating products from "virgin" feedstocks, recycling represents a net reduction in pollutants – and can be associated, through the concept of indirect costs, with a financial benefit or savings to society. The benefit of the recycling activity would be offset somewhat by cost or harm associated with operating the truck.

DEQ'S CALCULATION OF INDIRECT COSTS

In the present analysis, Oregon DEQ has calculated an indirect cost for each of the several dozen waste management scenarios under consideration. Because each waste management scenario is defined by its particular combination of materials, "dispositions" (e.g. recycling vs. landfilling) and transportation characteristics, this was a complex endeavor. The steps are summarized here, and more details are available in Appendix C.

First, Cascadia Consulting delivered its waste management scenarios to DEQ as a comprehensive database of materials, dispositions, and transportation characteristics.

These weight, disposition, and transportation data served as input to DEQ's Waste Impact Calculator (WIC) model. WIC is an open-source, independently reviewed life cycle model about solid waste. Documentation and downloads are available at https://or-dept-environmental-quality.github.io/wic.

DEQ used WIC to calculate thirteen different environmental impacts for each of Cascadia's waste management scenarios: global warming, human toxicity (cancerous), eutrophication, acidification, ozone depletion, natural land transformation, smog air, ecotoxicity, metal depletion, fossil depletion, water depletion, human health (particulate air), and human health (non-cancerous).

Environmental impacts and indirect costs

COMPONENTS OF NET COST

Those environmental impacts were in turn converted to indirect costs by the application of “damage factors” drawn from the environmental literature. Damage factors express the financial cost (or benefit) associated with increases or decreases in environmental impact. DEQ used midpoint values of the damage factors found in two sources:

- For global warming, human toxicity (cancerous), eutrophication, acidification, ozone depletion, smog air, ecotoxicity, human health (particulate air), and human health (non-cancerous): Morris, Jeffrey. 2020. *Economic Damage Costs for Nine Human Health and Environmental Impacts* (https://srmginc.com/images/Final-DEQ-Metro-Report.pdf).
- For natural land transformation, metal depletion, fossil depletion, and water depletion: S&P Global TruCost, as part of the GaBi life cycle analysis system (https://sphera.com).

After this transformation, each of Cascadia’s several dozen waste management scenarios was characterized by an indirect cost expressed in dollars.

DEQ’s Calculation of Indirect Costs

Waste management scenarios
characterized as tons, dispositions, distances

↓

Waste Impact Calculator Model

↓

Waste management scenarios
characterized as 13 separate environmental impacts

↓

Damage cost factors for 13 different environmental impacts

↓

Waste management scenarios
characterized as dollars of indirect costs

Materials in and out of scope for scenario modeling

Scenario modeling doesn't include all waste generated in Oregon. This slide shows what is include and excluded.

INCLUDED MATERIALS

- ✓ **Recycling and garbage regulated by local governments**
- ✓ **Franchised, licensed, or permitted collection for:**
  - Single-family residential
  - Multifamily residential
  - Commercial
- ✓ **Self-haul by the public**
- ✓ **Solid waste / recycling depots**

EXCLUDED MATERIALS (everything else*)

- ✕ **C&D Debris**
- ✕ **Hazardous waste**
- ✕ **Tires, paint, e-waste, etc.**
- ✕ **Organics**
- ✕ **Motor oil**
- ✕ **Bottle Bill recovery**
- ✕ **Commercial recovery not regulated by local government** (e.g., compacted cardboard directly marketed by business, industrial plastic scrap recovery, private scrap metal recycling)
- ✕ **Litter and illegal dumping**

** Most scenarios do not change out-of-scope tons.*

Geographic areas used in the model

The tonnage and direct cost model divides Oregon into four geographic groupings based on current access to curbside recycling and location.

Group 1 – Metro Area	Group 2 – Willamette Valley, etc.	Group 3 – Other Areas With Curbside Recycling	Group 4 – Areas Without Curbside Recycling
All areas within the Metro urban growth boundary.	Areas with curbside collection in most of the Willamette Valley, the Oregon Coast south to Lincoln County, Deschutes County, Hood River County, and Wasco County.	All other areas with curbside collection, including some small towns from areas in Category 2 if they are distant from Portland and other population centers, such as the City of Oakridge in Lane County.	Areas currently without curbside collection or minimal curbside collection — served mainly by depots, if at all. Some portion of these areas gain curbside recycling in future scenarios.

Modeling outputs and limitations

MODEL OUTPUTS

The models output scenario profiles and comparison charts that let us forecast the impact of investments and policies in terms of direct and indirect costs and tons of materials properly recycled.

LIMITS OF THE MODELS

These models are the best available forecasting tools, but their ability to predict the future is limited by the available input data:

- Historical data on tonnages, recovery rates, costs, and customers
- Current data on markets and technology that constantly and rapidly changes
- Limited data on contamination rates in collected commingled recycling and bales sold to market
- Limited data on waste generator responses to changes in the recycling system
- For certain types of environmental impacts (such as marine debris), limited ability to evaluate damage costs
- For other types of environmental impacts, uncertainty in estimates of impacts and damage costs

While the models may not predict the exact recycling capture rate and costs of a future system in Oregon, we are confident that the results provide reliable directional information for comparing scenarios to inform policy decisions regarding the USCL and PRO depot acceptable materials lists.

See Appendix B for more information on the tonnage and direct cost modeling methodology.

See Appendix C for more information on the indirect cost modeling methodology and a discussion of uncertainty.

Scenario Overview

An overview of the scenarios modeled

Scenario overview

SELECTING SCENARIO CONCEPTS

What is a scenario? A “scenario” is a unique combination of variables:

- Materials accepted by local governments, on the Uniform Statewide Collection List (commingled list) and at PRO depots
- Mode of collection for glass
- Number and type of PRO depots
- Customer engagement efforts to reduce contamination
- MRF equipment, labor, and bale types
- End markets

DEVELOPING SCENARIOS

DEQ developed scenario concepts in several stages:

- **Baseline scenario (S00)**
  The baseline scenario reflects the current garbage and recycling system, including baseline levels of inbound and outbound contamination in commingled recycling and end-markets for marketed materials.
- **20 exploratory scenarios (S01-S20)**
  To provide insight on anticipated policy questions and inform recommendations, in March 2022 DEQ developed several scenario concepts to explore a range of possible approaches and the impacts of step-wise changes in single variables. Compared to the baseline, all future scenarios include additional contamination reduction efforts, additional on-route recycling customers in some areas that lack on-route service, upgraded MRF designs to achieve higher quality bales, and responsible end markets. As a result, comparing future scenarios against the baseline reflects changes more than just the accepted materials lists.
- **28 December 2022 rule concept scenarios (S21-S24)**
  After reviewing results from S01-S20, DEQ defined four additional scenario concepts to inform December rule concepts (for Jan. 11, 2023 Rule Advisory Committee meeting). These scenario concepts also added an “unders recovery system” to MRFs designed to capture more undersized items that would otherwise be lost to residuals. As a result, comparisons against S01-S20 reflect more changes than just the accepted materials list and PRO depots.
- **“Zero Recycling” scenario (S25)**
  This scenario reflects no "in scope" recycling happening in Oregon and was designed to inform DEQ's rule concept on "practicability" (associated with DEQ's language around "responsible end markets").

Note: Limited analysis of additional scenarios is possible and may be conducted if the final rules deviate significantly from the December 2022 rule concepts.

Scenario Overview

69 MATERIALS (GROUPED)

CORE USCL

Glass

PET, HDPE, PP tubs

PET clamshells (thermoforms)

Polycoated cartons & cups

HDPE, PP, PET pails & cups

Rigid PS, other food serviceware

Aerosols

Bulky HDPE, PP products

Lids & film

Aluminum foil & foil products

Shredded paper

Block EPS

Propane canisters

4 COLLECTION METHODS

USCL
commingled collected on-route and at depots

OTS
glass collected on-the-side (on-route)

PRO depot
producer-funded depots collecting several materials

On-the-side and PRO depots
collected on-the-side and/or through producer-funded depots collecting several materials

3 DEPOT DENSITIES

PRO High
Highest number of depot locations

PRO Medium
Medium number of depot locations

PRO Low
Lowest number of depot locations

Material Categories Expanded

CORE USCL

- Recyclable OCC & Kraft paper
- Office paper, printing/writing paper, newsprint, magazines, phone books, paperback books
- Non-polycoated paperboard and molded pulp (excluding food serviceware), e.g., cracker boxes and egg cartons
- Packaging tissue paper and non-metalized gift wrap
- Aluminum/steel cans and small scrap metal
- PET, HDPE, and PP bottles and jars

Excludes items less than 6 ounces or 3” in two directions

Glass

- Bottles and jars

PET, HDPE, PP tubs

- Tubs
- Excludes food serviceware

PET clamshells (thermoforms)

Polycoated cartons & cups

HDPE, PP, PET pails & cups

- Pails and buckets 2-5 gallons
- Nursery containers
- Clear cups
- LDPE bottles and tubs

Rigid PS, other food serviceware

- LDPE and PS nursery containers
- PS packaging and cups
- PP & PET food serviceware (excluding cups)

Aerosol cans (empty)

Bulky HDPE, PP products

Lids & film

- Tub and container lids
- HDPE 6-pack carriers
- PE film/wrap

Aluminum foil & pressed foil products

Shredded paper

Block EPS foam

Propane canisters

ACRONYMS	
EPS	Expanded polystyrene (foam)
HDPE	High-density polyethylene (resin code #2)
LDPE	Low-density polyethylene (resin code #4)
OCC	Old corrugated cardboard/containers
PET	Polyethylene terephthalate (resin code #1)
PP	Polypropylene (resin code #5)
PS	Polystyrene (resin code #6)
USCL	All materials on Oregon’s uniform statewide collection list

Overview of modeled scenarios

	00	01	02	03	04	05	06	07	08	09	10	11	12
CORE USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL
Glass	On the side	On the side	On the side	On the side	On the side in Grouping 1 & PRO depot in Groupings 2-4	PRO depots – medium density	On the side	On the side	On the side	On the side in Grouping 1 & PRO depot in Groupings 2-4	On the side in Grouping 1 & PRO depot in Groupings 2-4	On the side in Grouping 1 & PRO depot in Groupings 2-4	On the side
PET, HDPE, PP tubs	Varies by grouping	Not accepted	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	PRO depots – medium density
PET clamshells (thermoforms)	Not accepted	Not accepted	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	PRO depots – medium density
Polycoated cartons & cups	Varies by grouping	Not accepted	Not accepted	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	PRO depots – medium density
HDPE, PP, PET pails & cups	Varies by grouping	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density
Rigid PS, other food serviceware	Varies by grouping	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density
Aerosols	Varies by grouping	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density
Bulky HDPE, PP products	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted
Lids & film	Varies by grouping	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density
Aluminum foil & foil products	Varies by grouping	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density
Shredded paper	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density
Block EPS	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density	PRO depots – low density	PRO depots – high density	PRO depots – medium density
Propane canisters	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted

	13	14	15	16	17	18	19	20	21	22	23	24	25
CORE USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Not accepted
Glass	On the side	On the side	On the side	On the side	On the side	On the side	On the side	On the side	PRO depots – high density	PRO depots – high density	PRO depots – high density	PRO depots – high density	Not accepted
PET, HDPE, PP tubs	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Not accepted
PET clamshells (thermoforms)	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted
Polycoated cartons & cups	PRO depots – medium density	Not accepted	PRO depots – medium density	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Not accepted
HDPE, PP, PET pails & cups	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	Commingled in USCL	Commingled in USCL	Not accepted	Not accepted	Not accepted	Commingled in USCL	Commingled in USCL	Commingled in USCL	Commingled in USCL	Not accepted
Rigid PS, other food serviceware	PRO depots – medium density	PRO depots – medium density	Not accepted	Commingled in USCL	Commingled in USCL	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted
Aerosols	PRO depots – medium density	PRO depots – medium density	Not accepted	Commingled in USCL	Commingled in USCL	Not accepted	Not accepted	Not accepted	PRO depots – medium density	Commingled in USCL	PRO depots – medium density	PRO depots – medium density	Not accepted
Bulky HDPE, PP products	Not accepted	Not accepted	Not accepted	Commingled in USCL	Commingled in USCL	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted
Lids & film	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	Not accepted	PRO depots – medium density	Not accepted	Not accepted	Not accepted	PRO depots – high density	PRO depots – high density	PRO depots – high density	PRO depots – high density	Not accepted
Aluminum foil & foil products	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	Not accepted	PRO depots – medium density	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – medium density	Commingled in USCL	PRO depots – medium density	Not accepted
Shredded paper	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	Not accepted	PRO depots – medium density	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	Not accepted
Block EPS	Not accepted	PRO depots – medium density	PRO depots – medium density	Not accepted	PRO depots – medium density	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	Not accepted
Propane canisters	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	Not accepted	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	PRO depots – medium density	Not accepted

KEY@

- Commingled in USCL
- On the side
- On the side in Grouping 1 & PRO depot in Groupings 2-4
- PRO depots – medium density
- PRO depots – low density
- PRO depots – high density
- Not accepted
- Varies by grouping

Notes:

- S18: glass is collected only in a dedicated glass-only truck
- S19: glass is collected only in a compartment on the side of the commingled truck
- S20: less glass is available curbside because the Bottle Bill is expanded

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Scenario Comparison Overview

Comparing scenarios to understand impacts of changing which materials are collected for recycling and how they are collected

Why compare subsets of scenarios?

IN-DEPTH ANALYSIS

DEQ is using this economic and environmental impact modeling to inform its recommendations around the range of materials to be accepted for recycling as well as how they are collected. Comparing costs and impacts across subsets of scenarios helps to answer questions involving specific materials and program elements by comparing the impacts of different options:

- **USCL length**: what are the impacts of adding more materials to the USCL, if there are no PRO depots.
- **USCL vs. PRO depots**: impacts of shifting materials between the USCL and PRO depots.
- **On-route vs. PRO depots**: impacts of collecting on-route versus at PRO depots only.
- **PRO depot density**: impacts of a larger or smaller network of PRO depots.
- **Specific materials**: impacts of recycling specific materials at all, particularly those that have historically posed challenges (such as polycoated cartons and cups and block EPS)

This section starts with overview charts comparing costs for all scenarios and four slides answering common questions about contamination, sortation costs, and PRO depot user driving. The next section shows 16 subsets of scenarios that DEQ selected to compare side by side.

SCENARIO COMPARISONS

The detailed scenario subset slides compare scenarios using four factors:

- **Direct costs**: in total (costs net of revenues).
- **Indirect costs**: shown here (for simplicity) in total only, not by lifecycle stage or impact factor.
- **Net costs**: in total (direct costs plus indirect costs).
- **Tonnages properly recycled:** show by material -- plastic, glass, metal, and paper.

Costs across scenarios

ABOUT COSTS

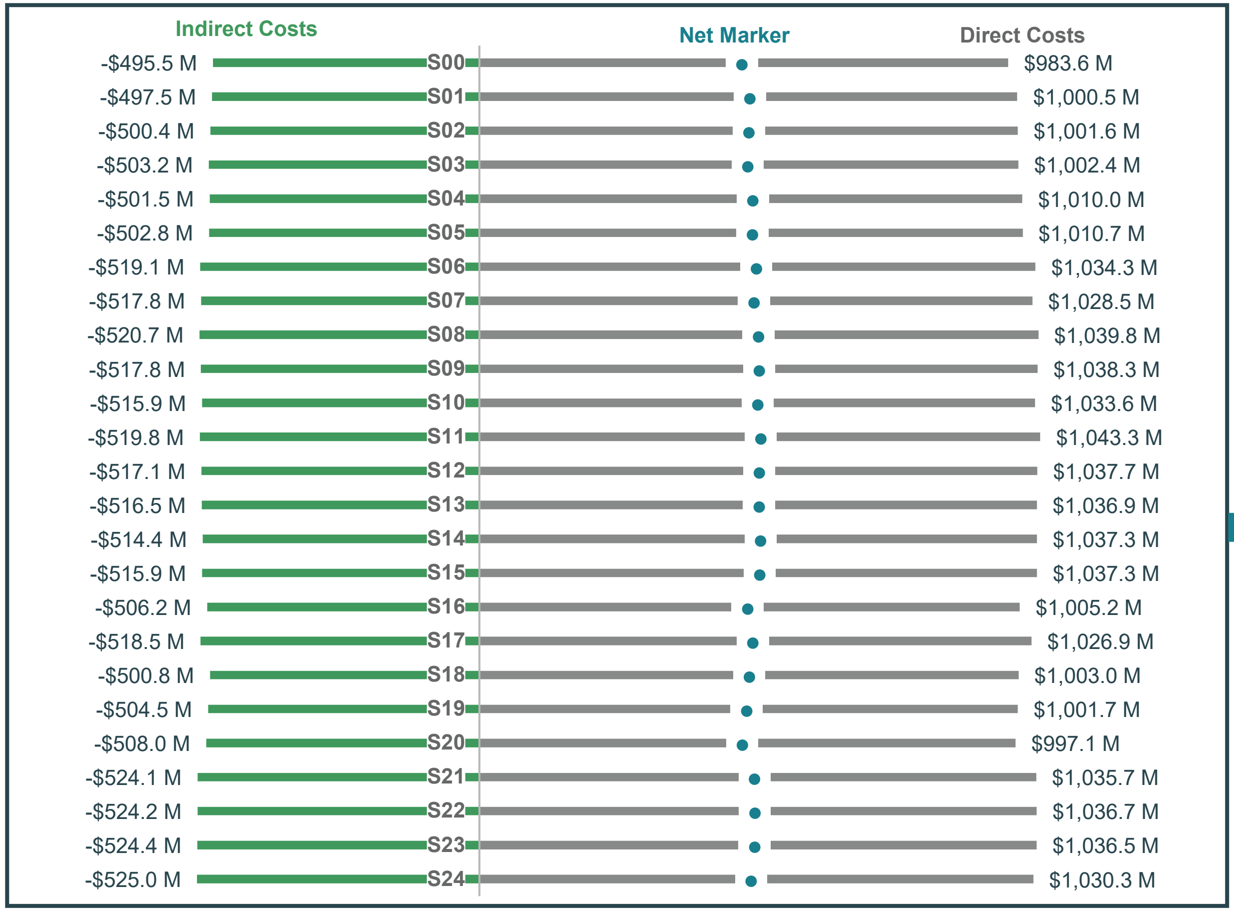
This chart shows cost modeling results for the baseline (S00), 24 future scenarios (S01-S24), and a “no recycling” scenario (S25).

- **Green bars** show indirect costs, which represent savings in S00-S24.
- **Gray bars show** direct costs
- **Blue dots** show net costs (indirect + direct costs)
- **Blue bars** zoom in on net costs with shortened axis to highlight the differences between scenarios

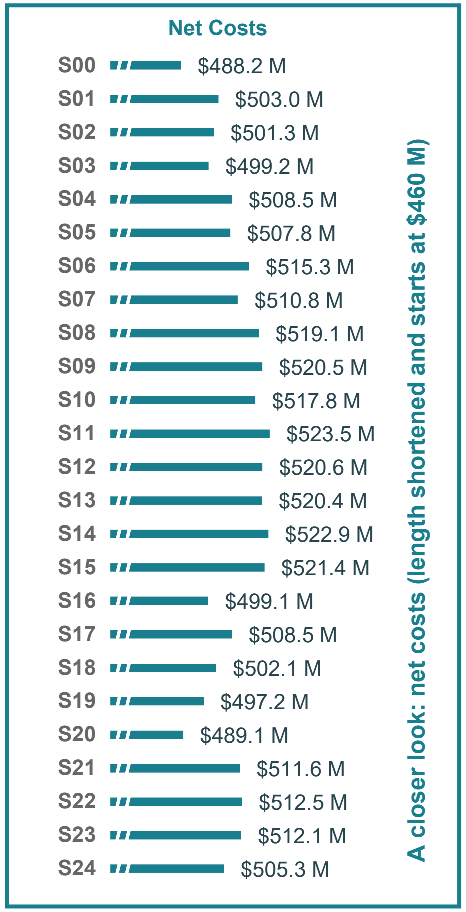
While difference in costs between scenarios are often within the margin of error, there are two key take-aways:

- The largest difference in net costs is between scenarios with recycling and the “no recycling” scenario.
- More recycling is typically better than less recycling, with some exceptions.

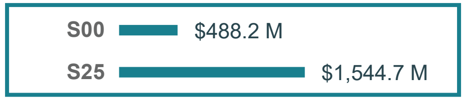
INDIRECT AND DIRECT COSTS BY SCENARIO



NET COSTS COMPARED



Charts below use a different scale than charts above. Additionally, the net cost chart below starts at $0 and is not shortened.



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FAQ: Contamination Rates in Recycling Collected Commingled

WHAT ABOUT CONTAMINATION IN COLLECTED RECYCLING?

Inbound contamination is the tons of materials not on the accepted materials list that are collected in commingled recycling divided by the total tons collected in commingled recycling.

$$\textit{Inbound contamination rate} = \frac{\textit{tons of unaccepted materials collected in commingled or USCL}}{\textit{total tons collected in commingled or USCL}}$$

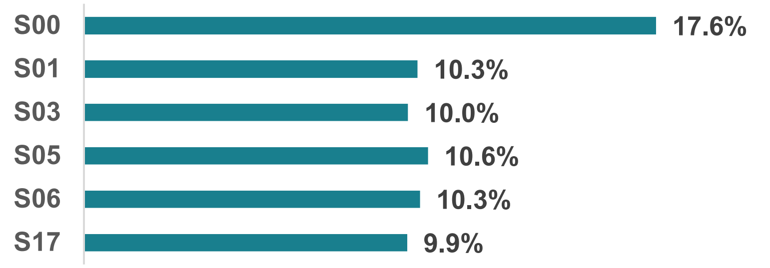
- Some materials, such as **food and diapers**, are **always contamination** because they are never on any accepted materials list.
- Some materials, such as **newspaper and PET bottles**, are **never contamination** because they are on every accepted materials list.
- Some materials, such as **polycoated cartons and clear polypropene cups**, are sometimes contamination and sometimes accepted.

WHAT DOES THE MODEL TELL US ABOUT INBOUND CONTAMINATION?

Modeling results show a big decrease in the USCL contamination rate between the baseline (S00) and all future scenarios (S01-S24) because all future scenarios assume additional and significant contamination reduction education funded by the Act. The differences among future scenarios are relatively small and reflect three factors:

- **List length**: Despite a lack of data showing a consistent impact of a longer list on contamination, the model uses the assumption people are more likely to put unwanted materials in commingled recycling when the list is longer. However, a longer list also means that fewer materials are unwanted. Therefore, when the list gets longer, the contamination rate can actually decrease, such as between **S01 and S03** and between **S06 and S17**.
- **Glass:** When glass is not accepted curbside, the model makes the conservative assumption that more will end up in commingled, increasing the contamination rate, such as between **S03 and S05.**
- **PRO depots**: When materials are accepted at PRO depots and not the USCL, the model assumes that some people will get confused and put more of those materials in commingled, such as between **S03 and S06**.

INBOUND COMMINGLED CONTAMINATION RATE



	List	Glass	PRO Depots
S00	Baseline	Curbside*	None
S01	Shorter	Curbside*	None
S03	Medium	Curbside*	None
S05	Medium	PRO depots	Glass-only
S06	Medium	Curbside*	Yes
S17	Longer	Curbside*	Yes

* Collected curbside but separate from the commingled stream

Appendix B summarizes evidence used to estimate the potential effectiveness of contamination reduction programming, which the Act requires the PRO to fund at $3 per Oregon resident per year.

FAQ: Contamination Rates in Outbound Bales from MRFs

WHAT ABOUT CONTAMINATION IN BALES?

Outbound (bale) contamination is the tons of materials that MRFs put into the wrong bale divided by the total tons marketed by MRFs.

$$\textit{Outbound contamination rate} = \frac{\textit{tons of materials put into the wrong bale by MRFs}}{\textit{total tons bales by MRFs}}$$

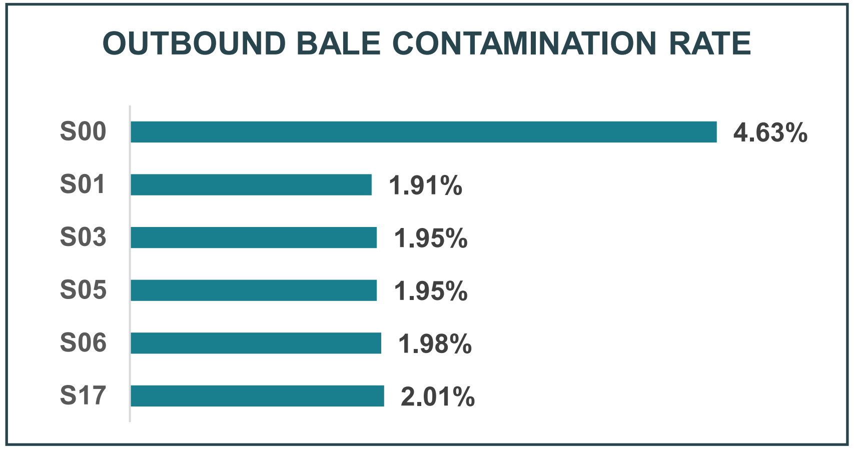
Bale contamination includes:
- Materials that never belong in any bale, such as diapers
- Materials that belong in a different bale, such as PET bottles in a mixed paper bale

The model assumes that DEQ will regulate MRFs by setting bale contamination limits of roughly 2% at full implementation. As a result, the Bales module sets bale contamination rates as a direct input, rather than a modeling output. Bale contamination rates for future scenarios were set to meet this target while considering three factors:
- Bale type (such as mixed paper or aluminum cans)
- Length of the USCL
- Collection stream (commingled, transferred containers, or mixed plastics from PRO depots)

In future scenarios in the Cost module, the consultant team added equipment and labor to MRFs that could reasonably achieve these bale contamination rates.

WHAT DOES THE MODEL TELL US?

Because bale quality is a modeling input for future scenarios, bale contamination rates do not vary much between them. However, there is a big decrease in outbound bale contamination between the baseline (S00) and all future scenarios (S01-S24) for three main reasons:
- Inbound contamination is reduced through generator-facing contamination reduction education
- Upgraded MRF equipment can sort materials better, including paper line upgrades at all MRFs and a new container recovery facility (CRF) line that plastics and cartons are transferred to
- All MRFs add an Artificial Intelligence (AI) quality control visioning system to inspect material as it is baled and identify bales that need to be re-sorted.



	List	Glass	PRO Depots
S00	Baseline	Curbside*	None
S01	Shorter	Curbside*	None
S03	Medium	Curbside*	None
S05	Medium	PRO depots	Glass-only
S06	Medium	Curbside*	Yes
S17	Longer	Curbside*	Yes

* Collected curbside but separate from the commingled stream

FAQ: Sortation costs across scenarios

WHY AREN'T PROCESSING COSTS INCREASING AS MUCH AS ONE MIGHT EXPECT?

Compared to the baseline scenario (S00), all future scenarios (S01-S24) were designed to achieve lower bale contamination rates (about 2%) and higher MRF capture rates (varied by material, but equal to or higher than in S00).

To achieve these standards, all future scenarios involve:

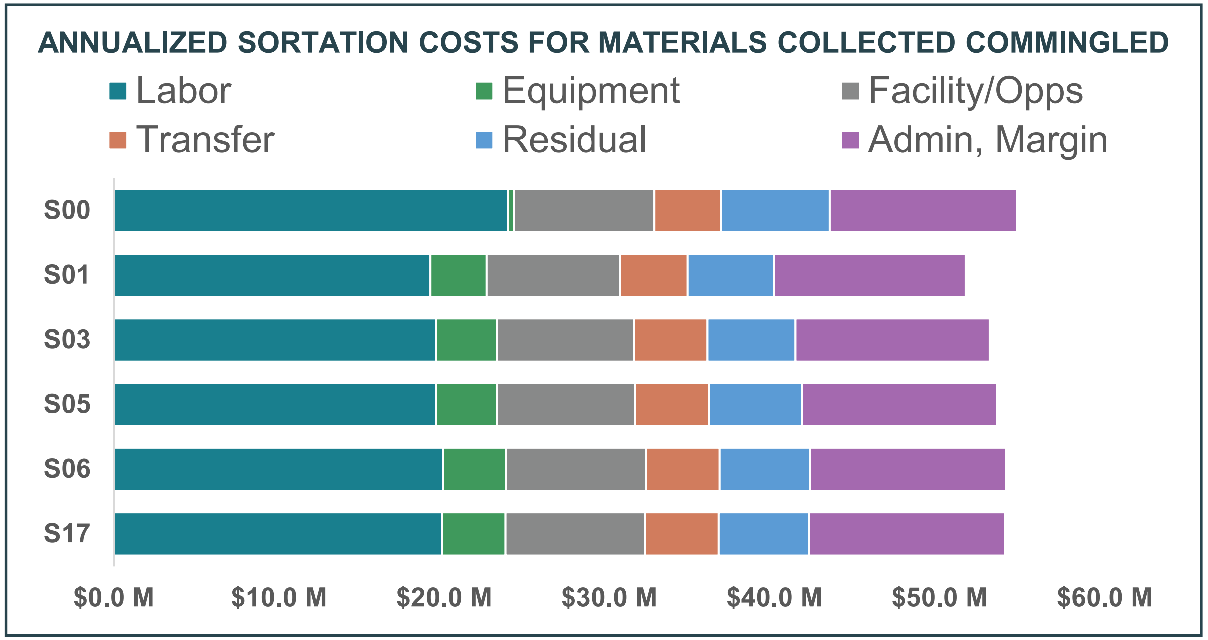
- New equipment at most MRFs, such as optical sorters for paper lines and AI quality control visioning systems
- A new CRF line focused on plastics, cartons, and other containers

At baseline (S00) annual equipment costs are relatively low because most existing equipment is already fully depreciated, so it creates no capital cost. It's like when a homeowner has paid off their mortgage, they no longer have that housing cost.

In future scenarios, equipment costs increase as MRFs purchase new equipment. At the same time, labor costs decrease as optical sorters replace some of the manual sorters. Future labor costs decrease even with added equipment maintenance workers. Between the baseline (S00) and S17, sort-line workers decrease from 331 to 244 while maintenance and equipment operator workers increase from 114 to 123.

As a result, when added together, equipment and labor costs in future scenarios tend to be slightly lower than these costs in the baseline.

Although the upfront costs will be high, investing in processing technology can reduce the need for manual sorting, which exposes workers to health and safety risks such as repetitive motion injuries and needle sticks.



Costs in this chart represent annualized costs. Equipment costs are depreciated over 10 years.

	List	Glass	PRO Depots
S00	Baseline	Curbside*	None
S01	Shorter	Curbside*	None
S03	Medium	Curbside*	None
S05	Medium	PRO depots	Glass-only
S06	Medium	Curbside*	Yes
S17	Longer	Curbside*	Yes

* Collected curbside but separate from the commingled stream

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FAQ: depot user driving across scenarios

WHAT'S UP WITH USERS DRIVING TO PRO DEPOTS?

The Act directs the EQC to define a list of materials that PROs must collect at depots or other similar locations, as well as collection targets, convenience standards, and performance standards for such collections. DEQ wondered if depot collection, which requires many individuals to drive personal vehicles many miles to aggregate one ton of material, could be environmentally justified given the added impacts of that personal vehicle use.

DEQ used the model to assess the economic and environmental impacts of two key variables: which materials and how many collection points?

> ***How do materials and collection points affect direct costs?***
>
> Generally speaking, **direct costs of depot service increase as the number of materials accepted and the number of collection points increase**.
>
> ***How do materials and collection points affect indirect costs?***
>
> The opposite dynamic is expected when environmental impacts are considered. **Accepting more materials for recycling leads to higher recovery and associated benefits of virgin resource displacement**.

Depots have relatively few impacts during operation, but a more robust network of collection sites results in higher convenience. That higher convenience also increases recycling (due to higher participation). Higher participation results in more vehicle trips by participants, but a larger number of collection points reduces the average mileage driven per trip, resulting in lower impacts per ton of material collected.

Appendix B provides additional information regarding data sources, modeling assumptions, and analysis of that dynamic.

The green graph compares the indirect costs for S03 (no PRO depots) to S07 (low number of depots), S06 (medium number), and S08 (high number). Indirect costs that are below zero, like in the chart above, represent benefits.

This graph suggests that the environmental benefits of depot collection outweigh the impacts of depot operation and vehicle use by depot users. Whether the number (and convenience) of depots is low, moderate, or high, the indirect costs of these scenarios are lower than those of a scenario that is identical except that it has no PRO depots. Indeed, as the number and convenience of depots increase, modeling shows that indirect costs fall slightly. This is a consequence of the benefits of higher recycling outweighing the added impacts of more (but shorter) user vehicle trips.

Scenario Comparisons

Comparisons of subsets of scenarios used to assess options

Understanding and comparing the scenarios

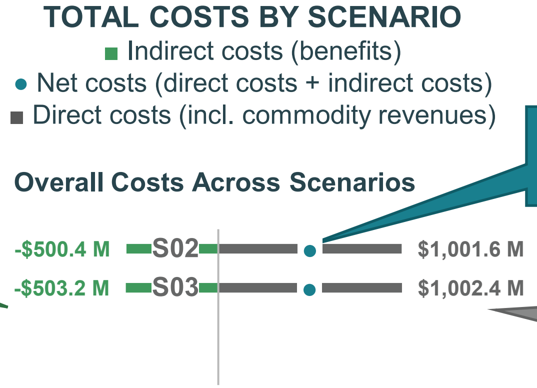
HOW TO UNDERSTAND THE SCENARIOS

The model estimates future tons collected, inbound contamination, tons properly recycled, direct costs, and indirect costs for each scenario. More importantly, it allows us to compare these results for different scenarios so that DEQ can shape policies and recommend investments with a better understanding of how costs, benefits, and impacts intersect.

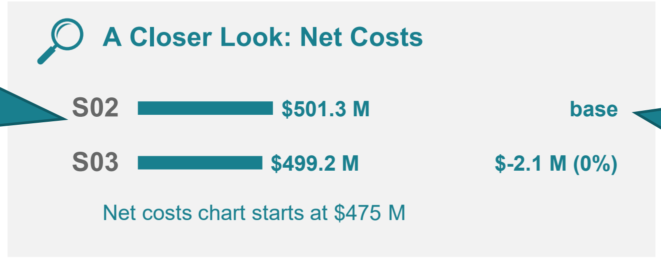
This section shows an example of how two scenarios compare in terms of:

- **Costs**: how much investment is required for success
- **Tons properly recycled**: what materials end up in which end-of-life scenarios

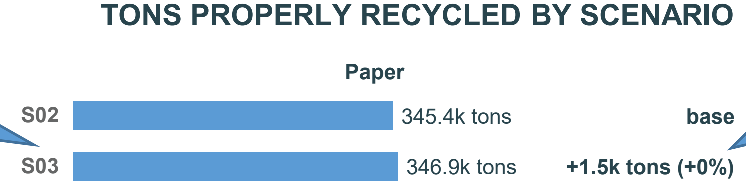
- The first cost graph shows direct, indirect, and net costs.



- The second graph zooms in on net costs.

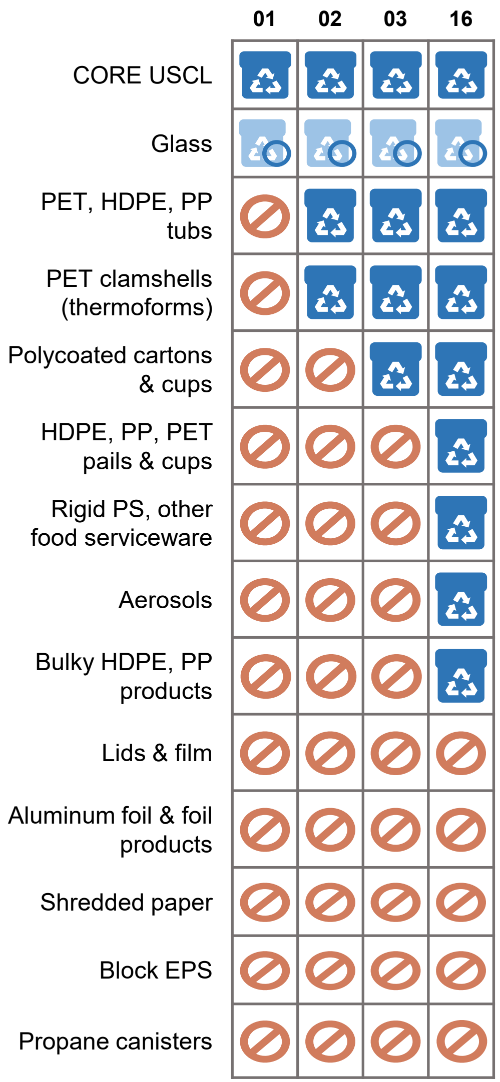


- Separate graphs show tons properly recycled by material for plastic, metal, glass, and (shown here) paper.



See **Appendix B** for consultant's methodology to estimate direct costs and **Appendix C** for DEQ's methodology to estimate indirect costs along with a discussion of uncertainty in the modeling.

S01, S02, S03, S16 – Cost Comparison



This comparison illustrates:

Impact of adding more materials to the USCL without adding PRO depots

USCL	Glass	PRO Depots	Tons that change
Increases	No change	Do not exist	Plastic, metal, paper

WHAT HAPPENS TO COSTS?

Overall, net costs decrease slightly when more materials are added to the USCL. Expanding the USCL increases the tons of material that are properly recycled and the direct costs associated with recycling. At the same time, shifting materials out of garbage trucks reduces garbage costs, primarily disposal fees. More recycling also reduces environmental impacts and associated indirect costs.

In these four scenarios, the extra savings in indirect costs and commodity revenues from recycling more tons is larger than the extra spending in direct costs for collection, transport, and sortation of a longer recycling list. However, as the list gets more complex, the extra spending may eventually outpace the extra savings. For example:

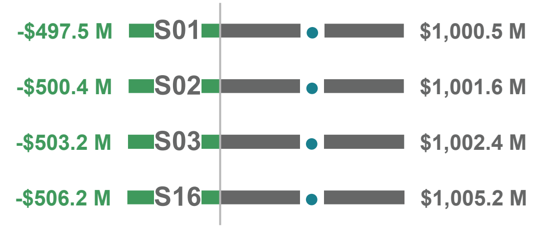
- Adding certain plastics (S02) to the core USCL (S01) reduces net costs by $1.8 million.
- Adding polycoated materials (S03) to S02 reduces net costs by another $2.1 million.
- But adding a broad mix of other materials (S16) to S03 reduces net costs by only another $0.1 million, due to increases in direct costs associated with more complex processing requirements.

Considering only the USCL, Scenario 03 most closely aligns with DEQ's proposed rule concept of Dec. 28, 2022.(That concept excludes PET thermoforms but includes certain pails and clear cups in the USCL.) Unlike the scenarios shown here, DEQ's propose rule concept also includes PRO depots.

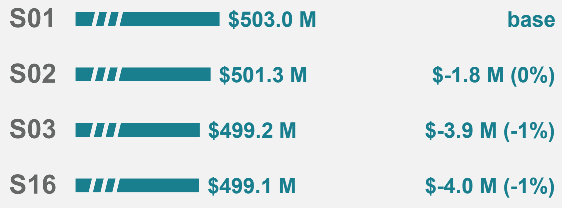
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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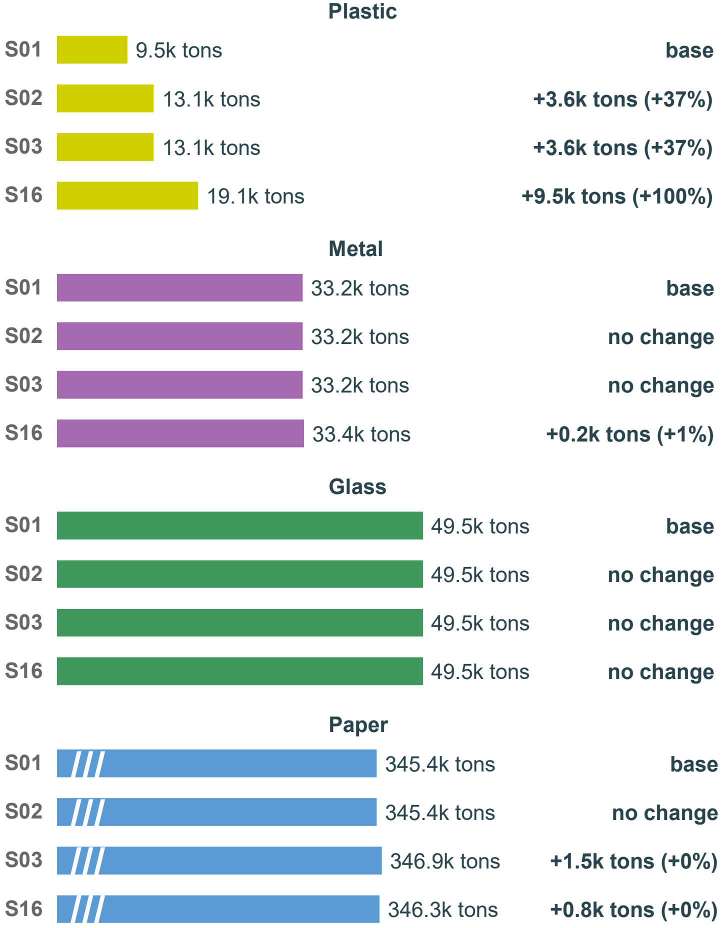
S01, S02, S03, S16 – Recovery by Material Comparison

TOTAL MATERIALS PROPERLY MARKETED
(in thousands of tons)



Paper chart starts at 250k tons

This comparison illustrates:

Impact of adding more materials to the USCL without adding PRO depots

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

Plastic tons properly recycled increase by 37% when PET, HDPE, and PP tubs are added to the USCL in S02/S03 and double (100% increase) in S16 when the USCL expands further to include pails and cups in these resins, certain bulky plastics, rigid polystyrene, PET clamshells, and other food serviceware.

Metal tons properly recycled barely change in S16 when aerosols are added to the USCL.

Paper tons properly recycled barely change in S03 and S16 when polycoated cartons and cups are added to the USCL. However, in S01 and S02, the polycoat is put into mixed paper bales and might ultimately end up in the landfill whereas in S03 and S16 they would be required to be sold to paper mills that will use the material. Tons of polycoated materials captured by MRFs is slightly lower in S16 (which has a more complex set of inbound materials to sort) than in S03 (which has a slightly simpler set of materials).

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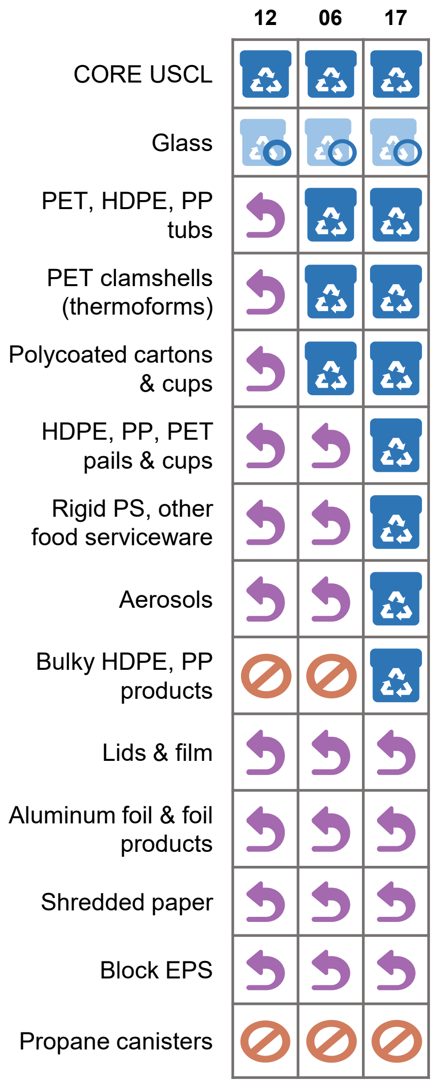
S12, S06, S17 – Cost Comparison



This comparison illustrates:

Impact of shifting materials from PRO depots to the USCL

USCL
Increases

Glass
No change

PRO Depots
Exist, decrease in materials accepted

Tons that change
Plastic, metal, paper

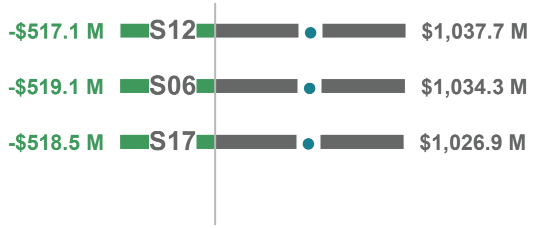
WHAT HAPPENS TO COSTS?

Overall, net costs decrease slightly by shifting materials from PRO depot collection to the USCL. Making recycling more convenient increases the tons of material that are properly recycled. There are savings in indirect costs and commodity revenues from more tons recycled. While sortation costs increase as the USCL gets more complex, overall direct spending on collection and transport decreases as PRO depots handle and transport fewer materials.

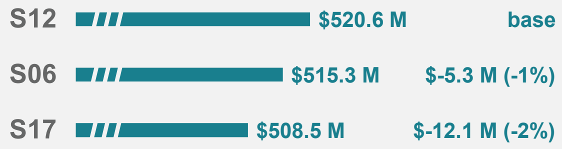
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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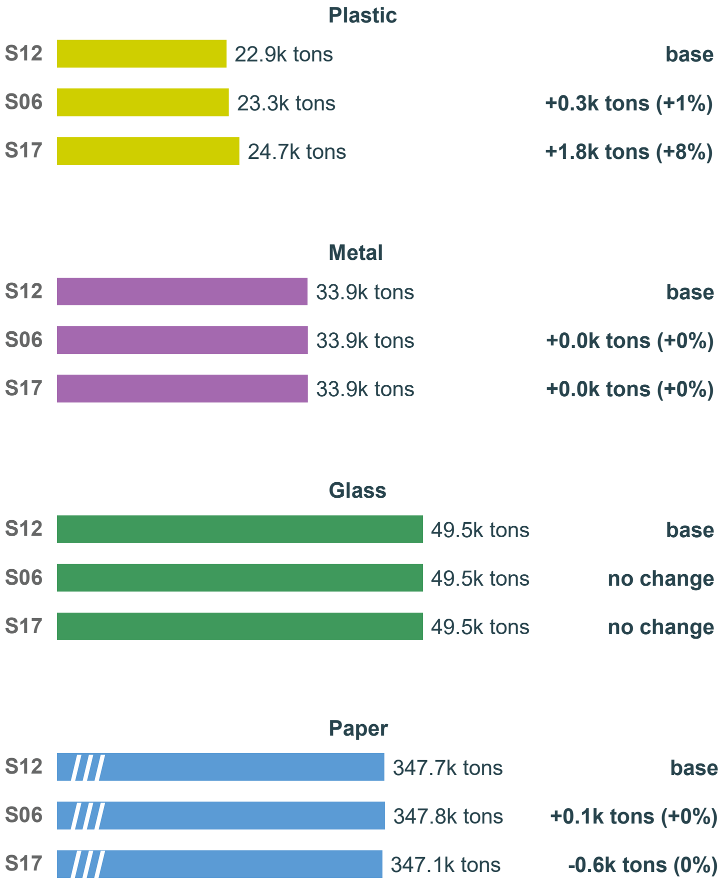
S12, S06, S17 – Recovery by Material Comparison

TOTAL MATERIALS PROPERLY MARKETED
(in thousands of tons)



Paper chart starts at 250k tons

This comparison illustrates:

Impact of shifting materials from PRO depots to the USCL

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

Shifting materials from PRO depots to the USCL increases tons collected for those materials but also means more is lost during sortation, reducing the gains for some materials.

Plastic tons: Several plastics present in comparatively large quantities are added to USCL in S06/S17, compared to just the core USCL in S12. Examples include clear PET, HDPE, and PP tubs and thermoforms. In S17, HDPE/PP Bulky is added to the USCL, much of which is captured during pre-sort.

Whether collected at depots or in the USCL, we assume all plastics require some form of sorting. When collected at depots, they are mixed only with other plastics, so we assume sorting is more efficient (higher capture rate, lower loss rate) than when they collected in the USCL mixed with all types of materials. As a result, for some plastics that are harder to sort, moving them from depots to USCL means additional losses at the MRF offset increased collection in the cart.

Metal tons: Metal tons increase slightly (less than 20 tons) in S17 when aerosols are accepted in the USCL.

Paper tons properly recycled increase slightly in S06 and decrease in S17. As polycoated cartons and cups are added to the USCL in S06, the slight increase in collected tons is not yet offset by losses during sortation but in S17 the longer list is more complex to sort, so additional collection is more than offset by losses during sortation. However, in S12, the polycoated material are put into mixed paper bales and might ultimately end up in the landfill whereas in S06 and S17 they would be required to be sold to paper mills that will use the material.

Additional analysis specific to polycoat only is the subject of the next several comparisons.

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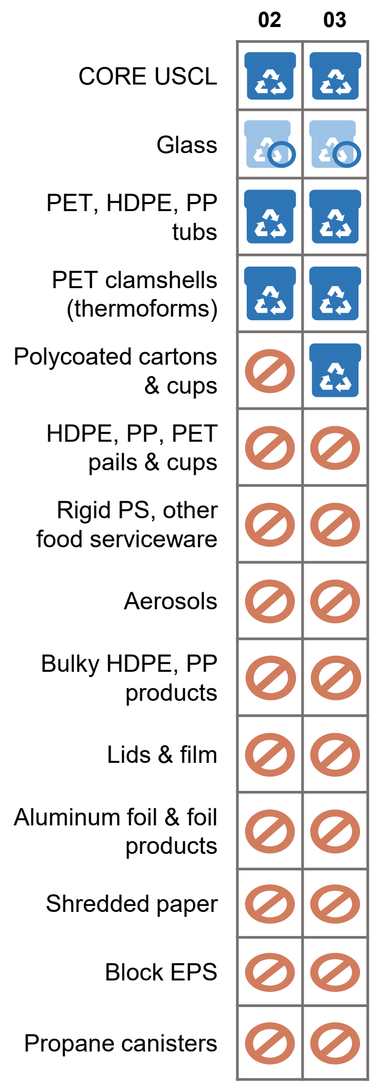
S02, S03 – Cost Comparison



This comparison illustrates:

Impact of collecting polycoat cups and cartons in the USCL

USCL	Glass	PRO Depots	Tons that change
Increases (add polycoat)	No change	Do not exist	Paper

WHAT HAPPENS TO COSTS?

In S03, cartons and cups are modeled to be primarily sorted optically into an aseptic and gable-tops only bale (Grade 52). A small percentage end up in the mixed paper bale.

Increases in direct costs associated with collection and sorting are partially offset by decreases in direct costs associated with collection and disposal of these cartons as garbage.

Net costs decrease by less than 0.5% (about $2.1M) as the slight increase in direct costs of collecting and sorting are more than offset by reductions in indirect costs. The reductions are associated with the high-quality fiber in cartons and cups, and the displacement of equally-high value fiber made from wood.

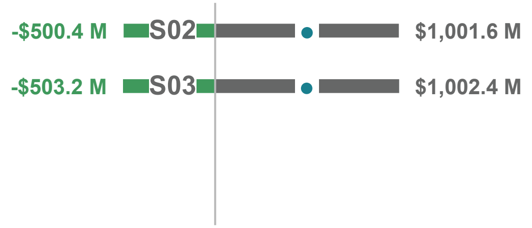
These economic differences are very small compared to the level of uncertainty in the costs.

DEQ has conducted a screening-level LCA for this material, available under meeting materials at www.oregon.gov/deq/recycling/Pages/Material-Lists.aspx (see Aug. 23, 2022 meeting presentation, starting at slide 94).

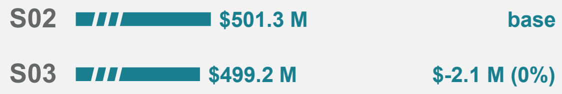
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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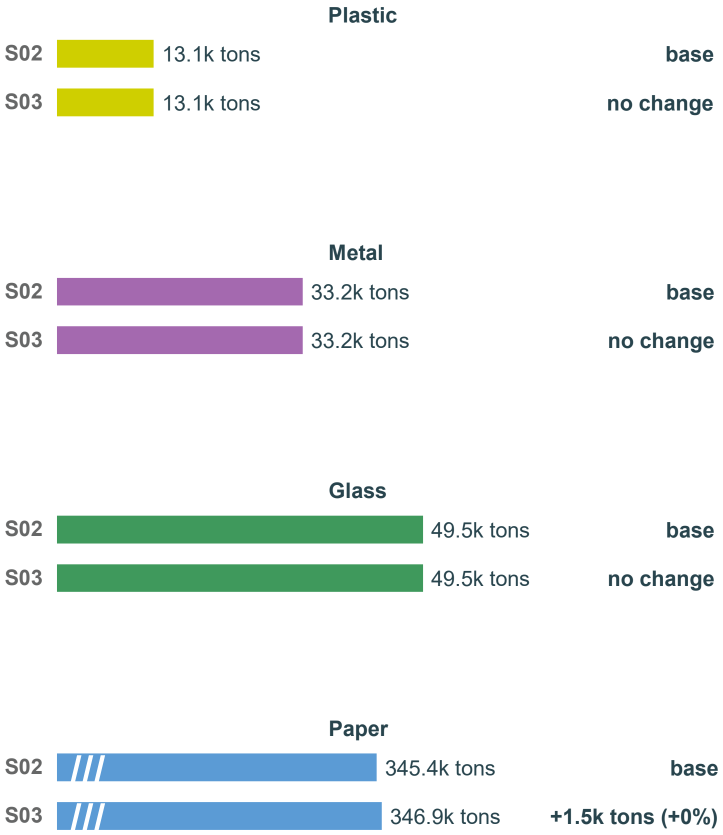
S02, S03 – Recovery by Material Comparison

TOTAL MATERIALS PROPERLY MARKETED
(in thousands of tons)



Paper chart starts at 250k tons

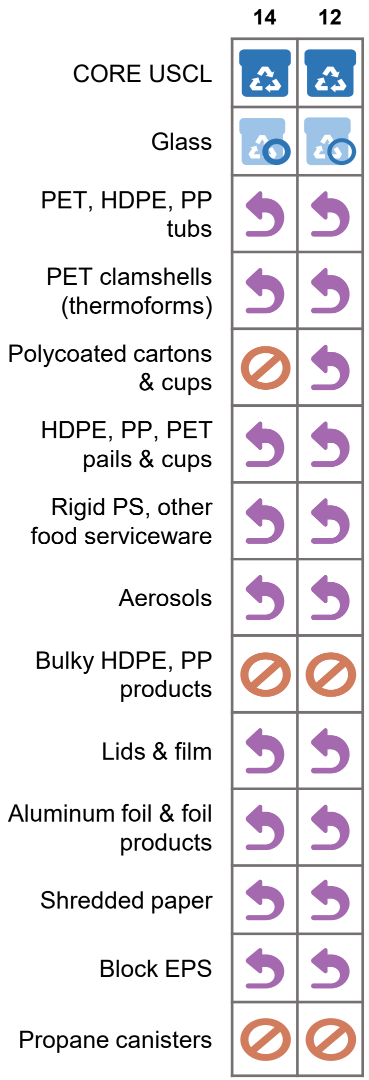
This comparison illustrates:

Impact of collecting polycoated cups and cartons in the USCL stream

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

Paper tons increase slightly, as about 1,500 more tons of cartons and cups are properly recycled.

S14, S12 – Cost Comparison



This comparison illustrates:

Impact of collecting polycoated cups and cartons (gable-top/aseptic) at PRO depots

USCL	Glass	PRO Depots	Tons that change
No change	No change	Exist, add polycoat	Paper (polycoat)

WHAT HAPPENS TO COSTS?

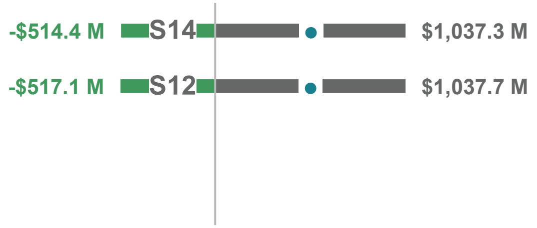
Net costs decrease by less than 0.5% (about $2.3M) as the slight increase in direct costs of collecting and transporting polycoated cartons and cups are more than offset by savings in indirect costs and commodity revenues. These differences are very small compared to the level of uncertainty in the costs.

DEQ has conducted a screening-level LCA for this material, available under meeting materials at www.oregon.gov/deq/recycling/Pages/Material-Lists.aspx (see Aug. 23, 2022 meeting presentation, starting at slide 94).

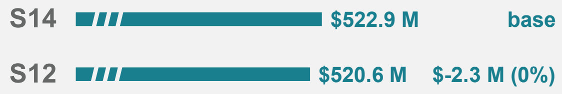
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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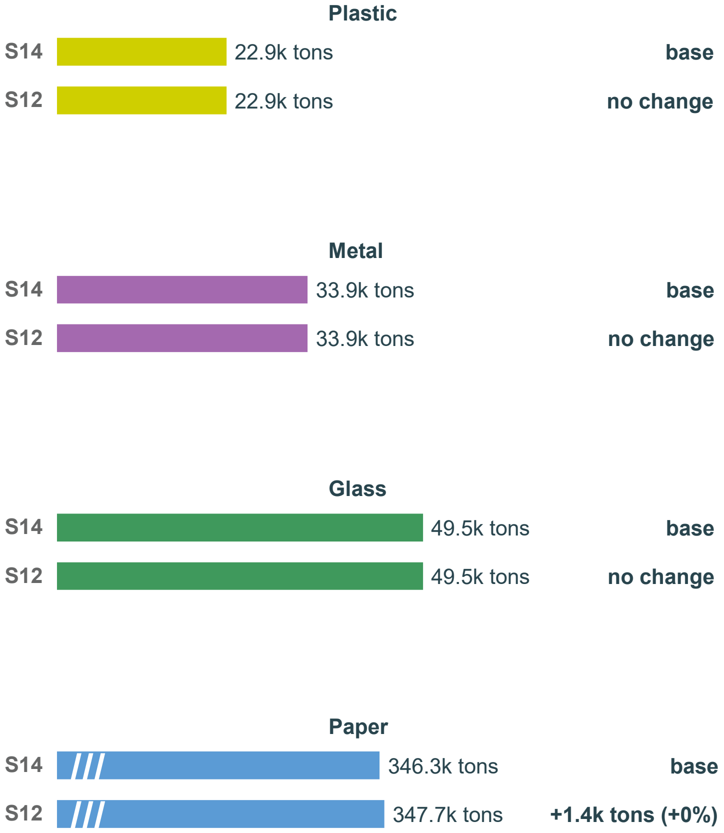
S14, S12 – Recovery by Material Comparison

TOTAL MATERIALS PROPERLY MARKETED
(in thousands of tons)



Paper chart starts at 250k tons

This comparison illustrates:

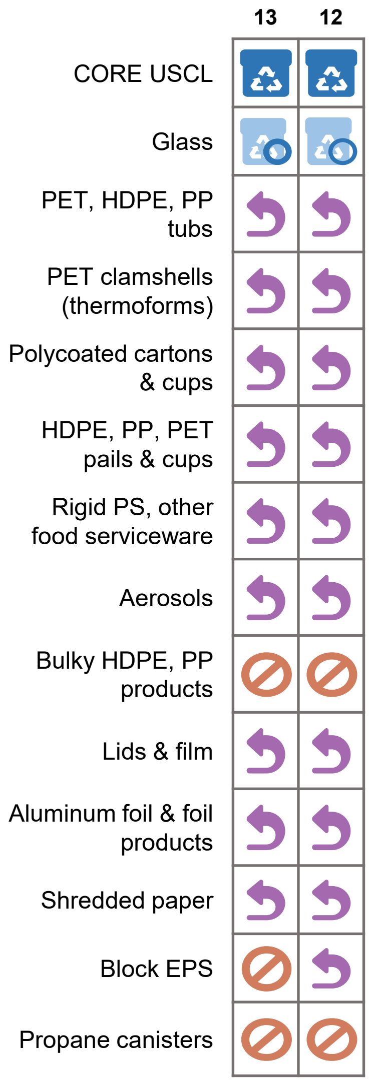
Impact of collecting polycoated cups and cartons (gable-top/aseptic) at PRO depots

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

Paper tons increase slightly, as about 1,400 more tons of cartons and cups are properly recycled.

The model assumes that polycoated cups and cartons are collected separately from other materials at PRO depots, so collected materials would not be lost to mis-sorting. In contrast, cups and cartons collected in the USCL and plastics collected at PRO depots or in the USCL require sorting, so not all of these materials that are collected end up properly marketed.

S13, S12 – Cost Comparison



This comparison illustrates:

Impact of collecting expanded polystyrene (EPS) foam at PRO depots

USCL	**Glass**	**PRO Depots**	**Tons that change**
No change	No change	Exist, add EPS	Plastic (EPS)

WHAT HAPPENS TO COSTS?

Net costs increase by less than 0.05% (about $0.2M) as the additional direct costs from collecting, transporting, and densifying EPS are almost entirely offset by savings in direct costs for garbage collection, transport and disposal, indirect costs and commodity revenues. These differences are very small compared to the level of uncertainty in the costs.

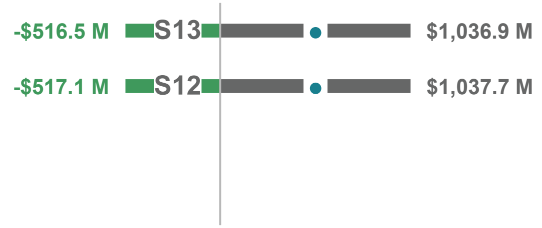
Modeling assumes that EPS is transported from PRO depots to one of several mechanical densifiers located around the state and densified before being transported longer distances to market. Consistent with state policy and requirements of the RMA, EPS is modeled to be recycled using mechanical and not chemical processes.

DEQ has conducted a screening-level LCA for this material, available under meeting materials at www.oregon.gov/deq/recycling/Pages/Material-Lists.aspx. The study shows potential for environmental benefits from mechanical recycling (compared to landfilling) so long as collection points are conveniently distributed and transport of un-densified EPS is minimized.

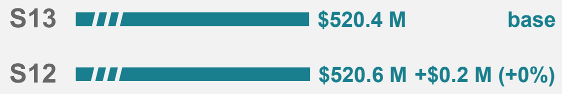
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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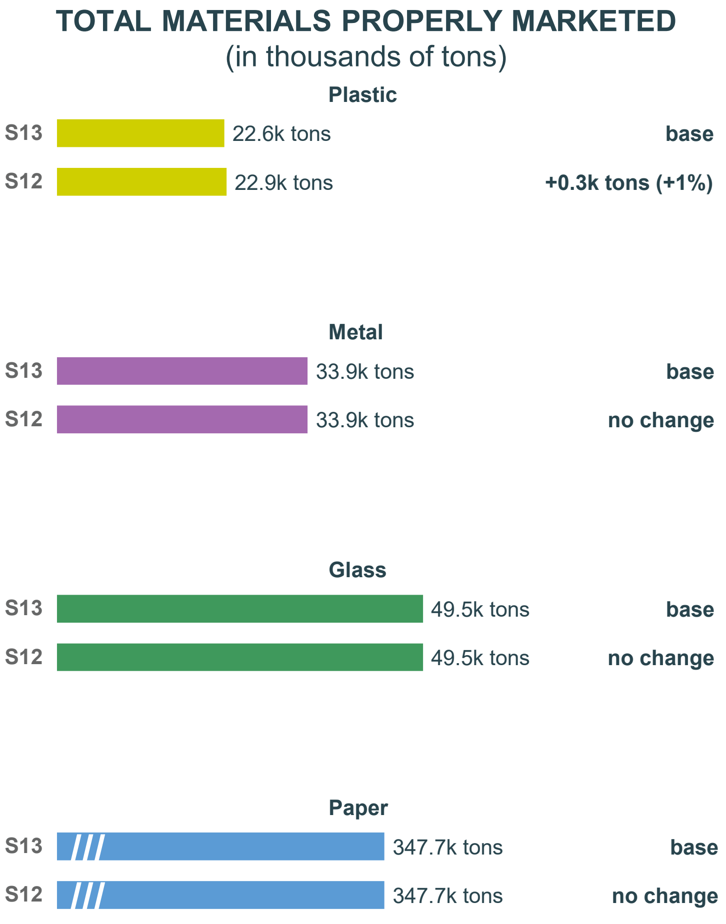
Circular Matters

S13, S12 – Recovery by Material Comparison



Paper chart starts at 250k tons

This comparison illustrates:

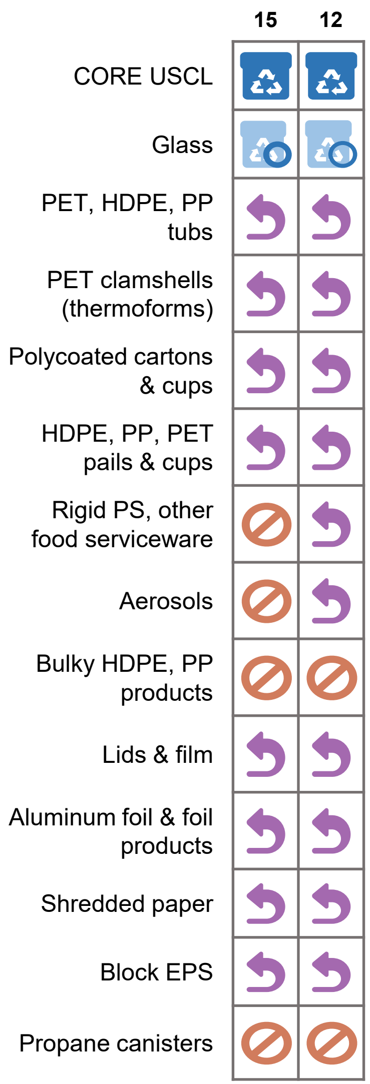
Impact of collecting expanded polystyrene (EPS) foam at PRO depots

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

Plastic tons increase slightly, as just under 300 more tons of EPS are properly recycled.

This particular estimate has higher uncertainty in it due to uncertainty in underlying waste generation data. The material is susceptible to under- or over-counting in waste composition studies because of the infrequent nature of how it is generated. Waste generation and resulting recycling potential may be higher than shown here. For example, Tillamook County operates a depot collection system for block white EPS foam that offers service at a level of convenience similar to that proposed in DEQ's rule concept. If the entire state of Oregon recycles this material at the same rate (pounds/person) as Tillamook County, statewide collections would be on the order of 1,000 – 1,300 tons per year. At the same time, the amount of EPS available for recycling in 2025 and subsequent years also has high uncertainty, as several brands have implemented or announced plans to eliminate use of this material.

S15, S12 – Cost Comparison



This comparison illustrates:

Impact of collecting rigid PS, other FSW, and aerosols at PRO depots

USCL	Glass	PRO Depots	Tons that change
No change	No change	Exist, add materials	Plastic and metal

WHAT HAPPENS TO COSTS?

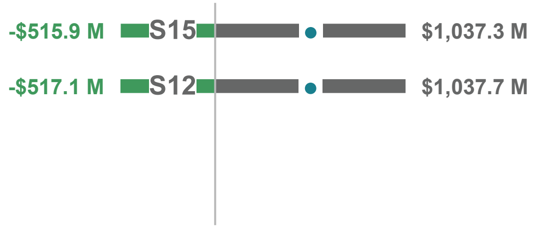
Net costs decrease by less than 0.2% (about $0.8M) as the additional direct costs from collecting, transporting, and processing these materials are more than offset by savings in indirect costs and commodity revenues. Direct costs include sorting the collected plastics at a MRF and draining the aerosols to manage the contents safely.

These differences are very small compared to the level of uncertainty in the costs.

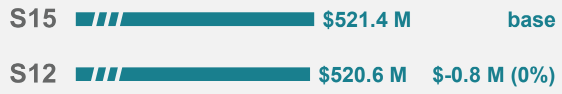
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios

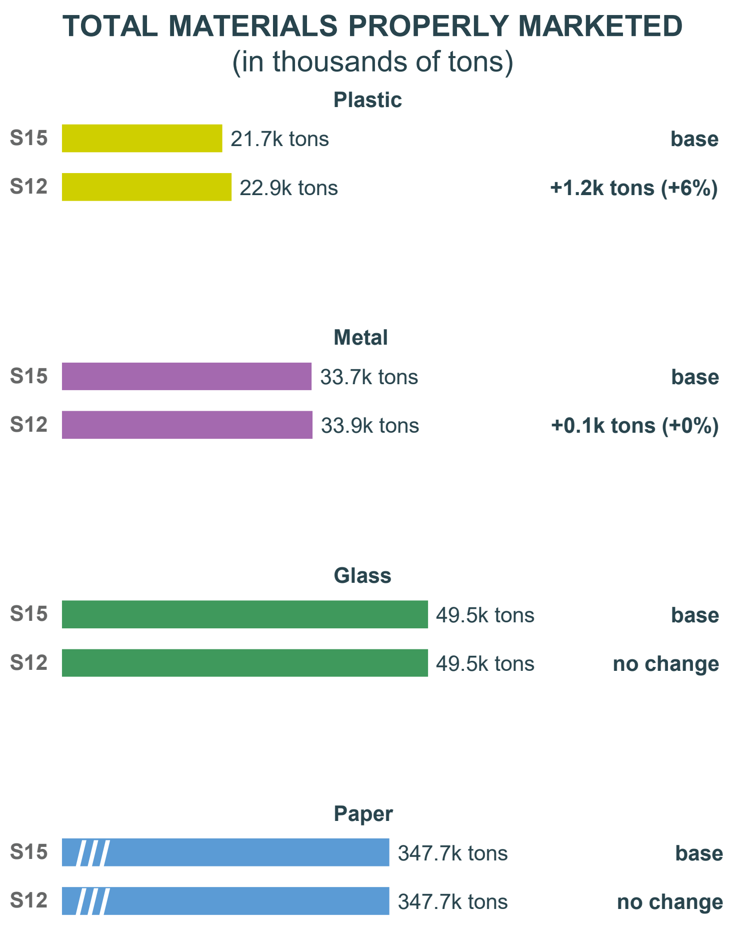


A Closer Look: Net Costs



Net costs chart starts at $475 M

S15, S12 – Recovery by Material Comparison



Paper chart starts at 250k tons

This comparison illustrates:

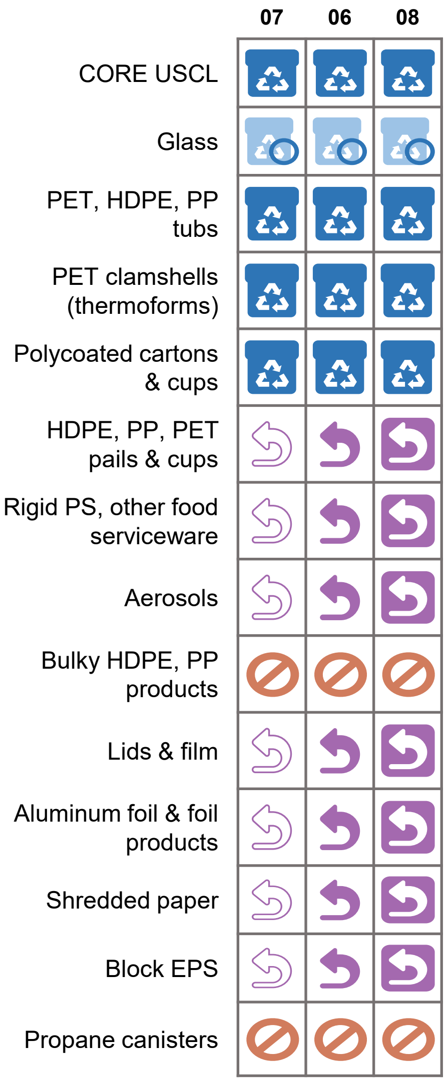
Impact of collecting rigid PS, other FSW, and aerosols at PRO depots

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

Plastic tons properly recycled increase slightly, about 1,200 more tons of rigid polystyrene and other foodservice ware are collected at PRO depots.

Metal tons properly recycled increase slightly, as just over 100 tons of aerosol cans are collected at PRO depots.

S07, S06, S08 – Cost Comparison



This comparison illustrates:

Impact of adding more PRO depots when glass is collected on-route

USCL	Glass	PRO Depots	Tons that change
No change	No change	Exist, add more locations	Plastic, metal, paper

WHAT HAPPENS TO COSTS?

Net costs increase slightly as the number of PRO depots increases compared to S07 – by less than 0.9% ($4.5M) in S06 (moderate number of depots) and by less than 1.7% ($8.4M) in S08 (largest number of depots). These differences are very small compared to the level of uncertainty in the costs.

As depots increase, the direct costs of operating those depots and handling and transporting the additional materials they collect increases faster than the savings in indirect costs and commodity revenues from increased recycling. Between S07 (fewest depots) and S08 (most depots), direct costs increase by about $11.3M while indirect costs decrease by about $2.9M.

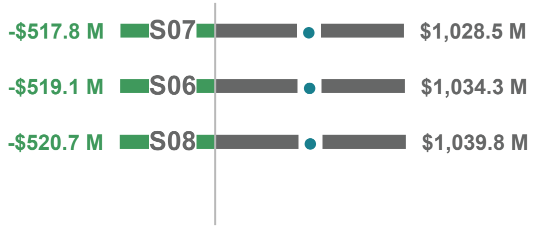
Adding depots increases convenience and improves environmental outcomes, but each additional depot provides a smaller gain in convenience – and therefore collected tons and indirect benefits – than depots added before it.

DEQ's proposed rule concept prioritizes greater convenience for Oregonians and environmental outcomes over economic considerations.

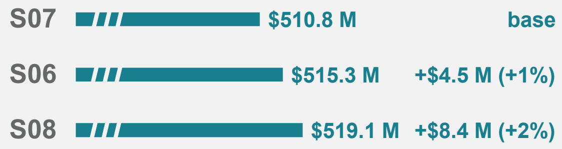
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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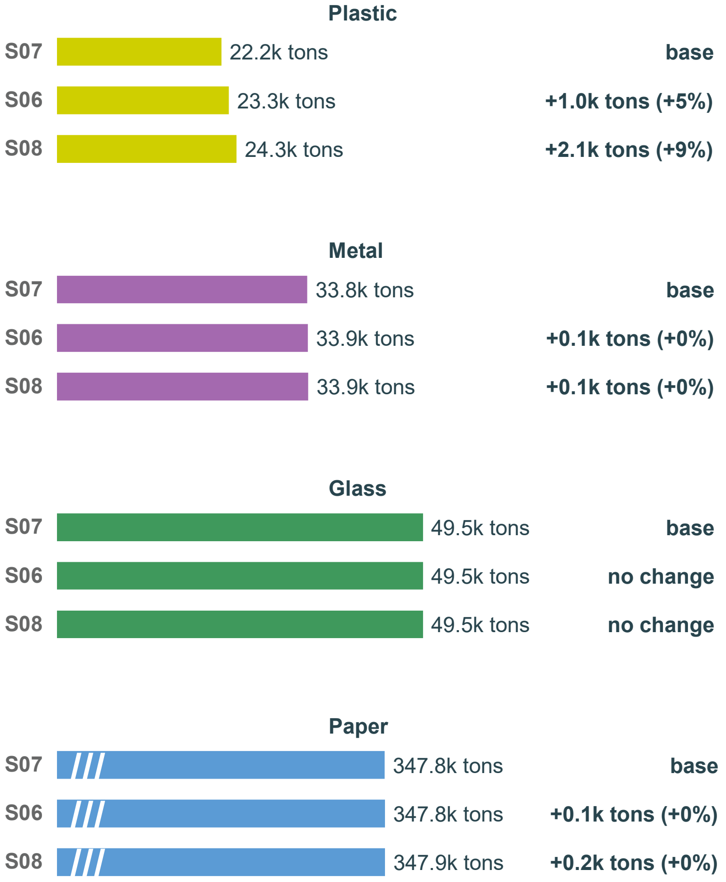
Bell & Associates

Circular Matters

S07, S06, S08 – Recovery by Material Comparison

TOTAL MATERIALS PROPERLY MARKETED
(in thousands of tons)



Paper chart starts at 250k tons

This comparison illustrates:
Impact of adding more PRO depots when glass is collected on-route

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

Tons of plastic and metal that are properly recycled increase to some extent as recycling of materials accepted at PRO depots becomes more convenient when more PRO depot locations are added to the network. Tonnage increases are driven by assumptions about how depot density affects convenience and collection capture rates.

The largest gain is in **plastic** (5% and 9%).

Metal and **paper** increase to a lesser extent because materials accepted at PRO depots represent a small share of generated tons.

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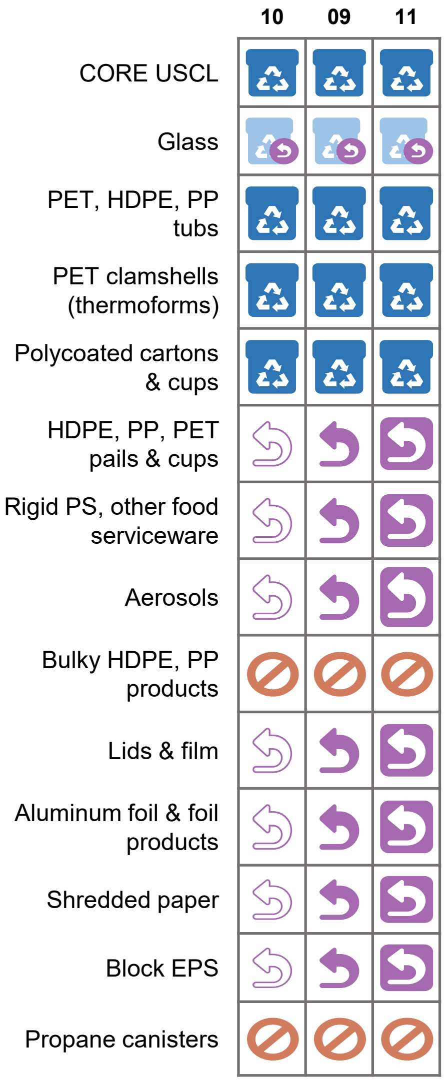
S10, S09, S11 – Cost Comparison



This comparison illustrates:

Impact of adding more PRO depots, when glass collected at depots outside Metro

USCL	Glass	PRO Depots	Tons that change
No change	No change	Exist, add more locations	Plastic, metal, glass, paper

WHAT HAPPENS TO COSTS?

This is similar to the preceding comparison except in this case, glass is collected at depots outside the Metro region.

Net costs increase slightly as the number of PRO depots increases compared to S10 – by less than 0.6% ($2.8M) in S09 (moderate number of depots) and by less than 1.2% ($5.7M) in S11 (largest number of depots). These differences are very small compared to the level of uncertainty in the costs.

As depots increase, the direct costs of operating those depots and handling and transporting the additional materials they collect increases faster than the savings in indirect costs and commodity revenues from increased recycling. Between S10 (fewest depots) and S11 (most depots), direct costs increase by about $9.6M while indirect costs decrease by about $3.9M.

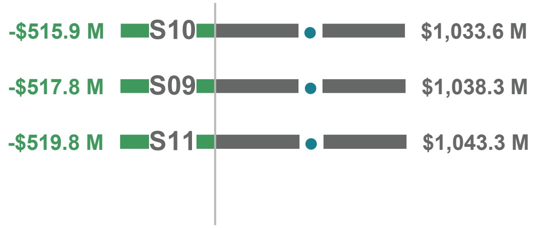
Adding depots increases convenience and improves environmental outcomes, but each additional depot provides a smaller gain in convenience – and therefore collected tons and indirect benefits – than depots added before it.

DEQ's rule concept prioritizes greater convenience for Oregonians and environmental outcomes over economic considerations.

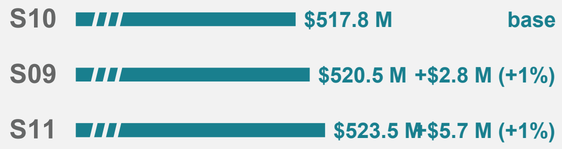
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs

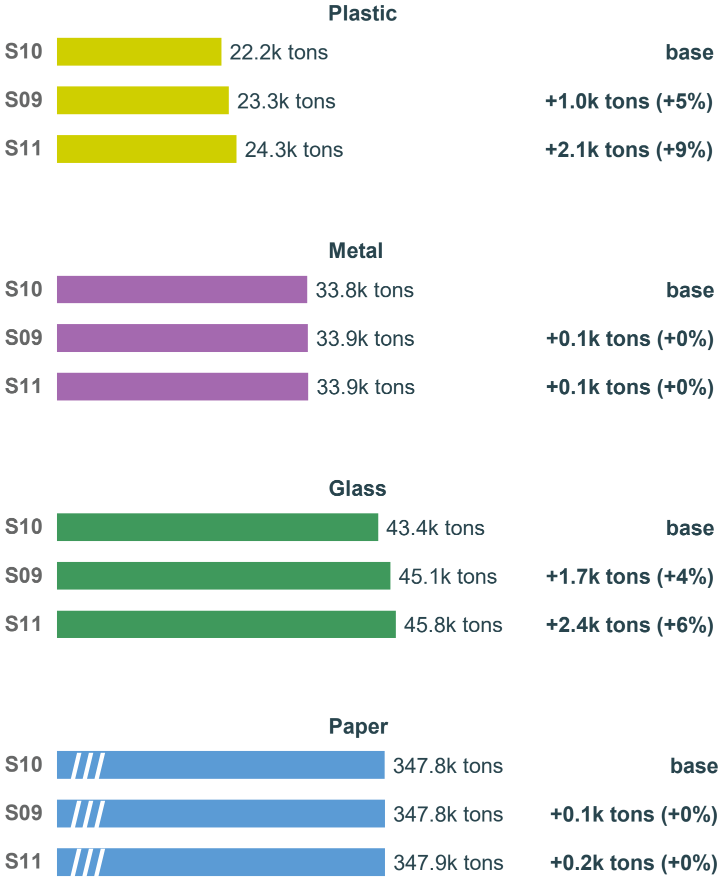


Net costs chart starts at $475 M

Bell & Associates

S10, S09, S11 – Recovery by Material Comparison

TOTAL MATERIALS PROPERLY MARKETED
(in thousands of tons)



Paper chart starts at 250k tons

This comparison illustrates:

Impact of adding more PRO depots, when glass collected at depots outside Metro

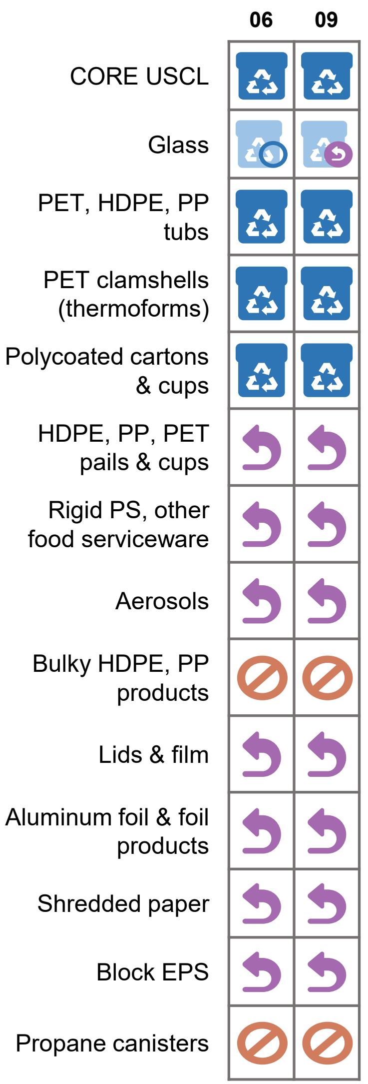
WHAT HAPPENS TO TONS PROPERLY RECYCLED?

All tons properly recycled increase to some extent as recycling of materials accepted at PRO depots becomes more convenient when more PRO depot locations are added to the network. Tonnage increases are driven by assumption about how depot density affects convenience and collection capture rates.

The largest gains are in **plastic** (5% and 9%) and **glass** (4% and 6%).

Metal and **paper** increase to a lesser extent because materials accepted at PRO depots represent a small share of generated tons.

S06, S09 – Cost Comparison



This comparison illustrates:

Impact of changing whether glass is collected on-route or at multi-material depots

USCL	Glass	PRO Depots	Tons that change
No change	Shifts to PRO depots	Exist, add glass	Glass

WHAT HAPPENS TO COSTS?

Net costs appear to increase as glass outside of Metro is shifted from on-route collection to PRO depots that accept both glass and other materials. Glass is collected on-route in Metro in both scenarios. This difference is small compared to the level of uncertainty in the costs.

When glass is added to existing multi-material PRO depots, direct costs increase overall. While depots themselves are less expensive to operate, savings from eliminating on-route collection may be offset from additional costs including customers transporting glass themselves to depots in personal vehicles. Such impacts are dependent upon the locations and convenience of depots to the public.

Indirect costs also may increase due to the emissions from customer vehicle use, and a modest decrease in the amount of glass recycling. A reduction in impacts from collection vehicle operation is modeled as offsetting some but not all of these increased impacts.

DEQ has conducted a screening-level LCA for this material, available under meeting materials at www.oregon.gov/deq/recycling/Pages/Material-Lists.aspx. It finds that on a per-ton basis, depot collection of glass in some cases may be environmentally preferable to on-route collection.

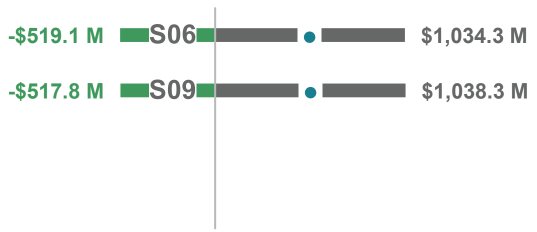
Glass is an unusual material because the per-ton savings in indirect costs of recycling glass are relatively low while the per-ton impacts of recycling it on-route are relatively high, due to use of separate trucks and/or separated compartments.

Uncertainty in all of these estimates is higher than for several other comparisons in this report. Cascadia and DEQ were only able to estimate the dynamics involving collection vehicles, which are particularly complex for dual-compartment vehicles. Transportation impacts associated with user behavior in a future network of depots is also uncertain. Adding to uncertainty are the possibility that Oregon's bottle bill may be expanded to include wine and/or liquor bottles (which would further reduce benefits of both on-route collection and depots) and the possibility that in the future collected glass could go to a pozzolan end market (which would increase the benefits of glass recycling).

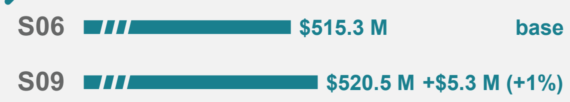
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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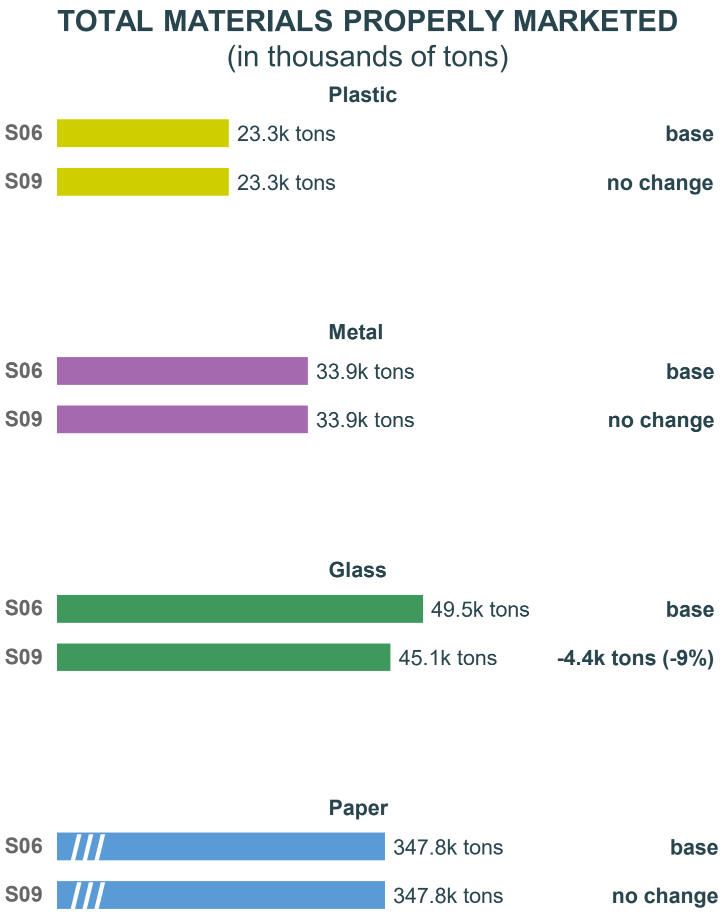
S06, S09 – Recovery by Material Comparison



Paper chart starts at 250k tons

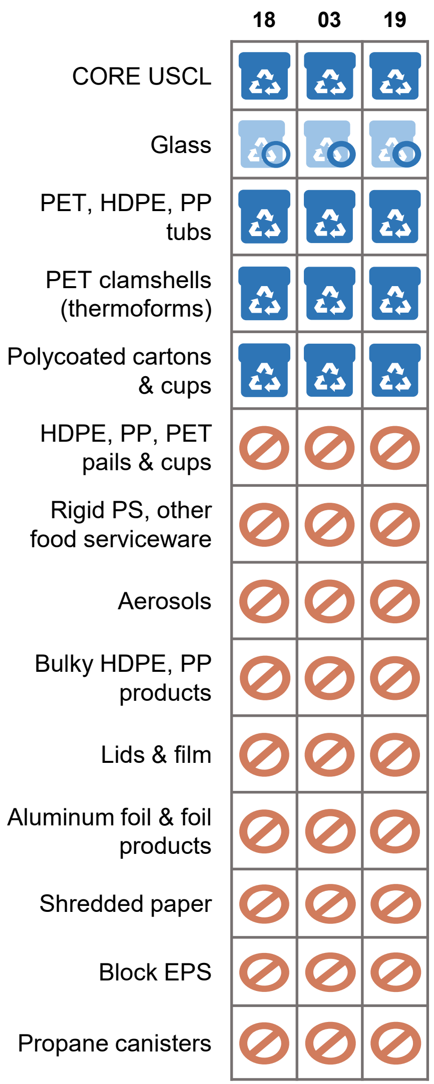
This comparison illustrates:

Impact of changing whether glass is collected on-route or at multi-material depots

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

As the convenience of recycling decreases, glass tons properly recycled decrease by 9% when glass is shifted to PRO depots outside of Metro.

S18, S03, S19 – Cost Comparison



This comparison illustrates:

Impact of changing the types of trucks used to collect on-route glass

USCL
No change

Glass
Change collection trucks

PRO Depots
Do not exist

Tons that change
None

WHAT HAPPENS TO COSTS?

In all three scenarios, glass is collected on-route, but the type of truck varies. S18 uses only dedicated glass-only trucks.

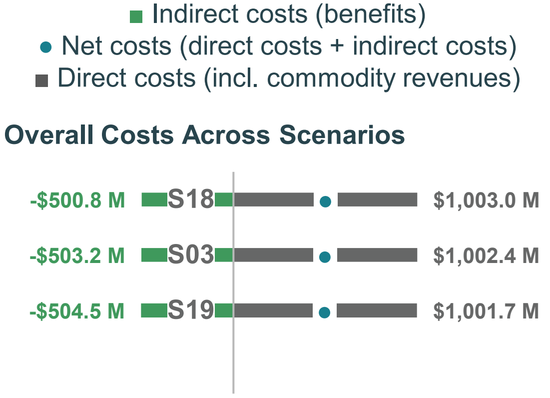
S03 uses the current mix of dedicated glass-only trucks and dual-compartment commingled trucks that have separate compartment for glass.

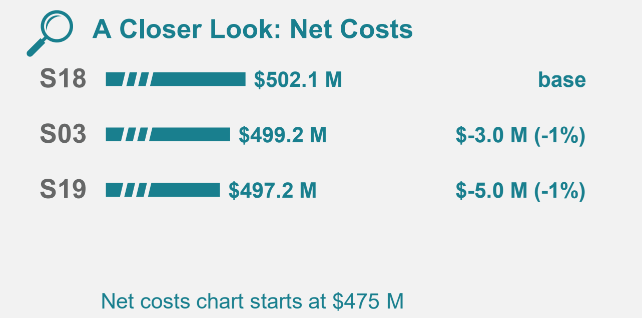
S19 uses only dual-compartment trucks.

Across these the scenarios, direct costs decrease by a negligible amount (less than 0.1% between S18 and S19). Indirect costs however decrease by several million dollars, reflecting the higher pollution associated with driving additional trucks in S18. These differences are relatively small compared to the level of uncertainty in the costs.

Based on consultant experience and research, on-route collectors primarily use dual-compartment trucks on residential routes. However, dual-compartment trucks can be less efficient when one compartment (either glass or commingled) fills up before the other. In this situation, the driver must stop collecting in order to empty the vehicle. On-route collectors typically use glass-only trucks on commercial routes where customers generate a lot of glass, such as restaurants. However, glass-only trucks are used in some residential routes in Oregon.

TOTAL COSTS BY SCENARIO





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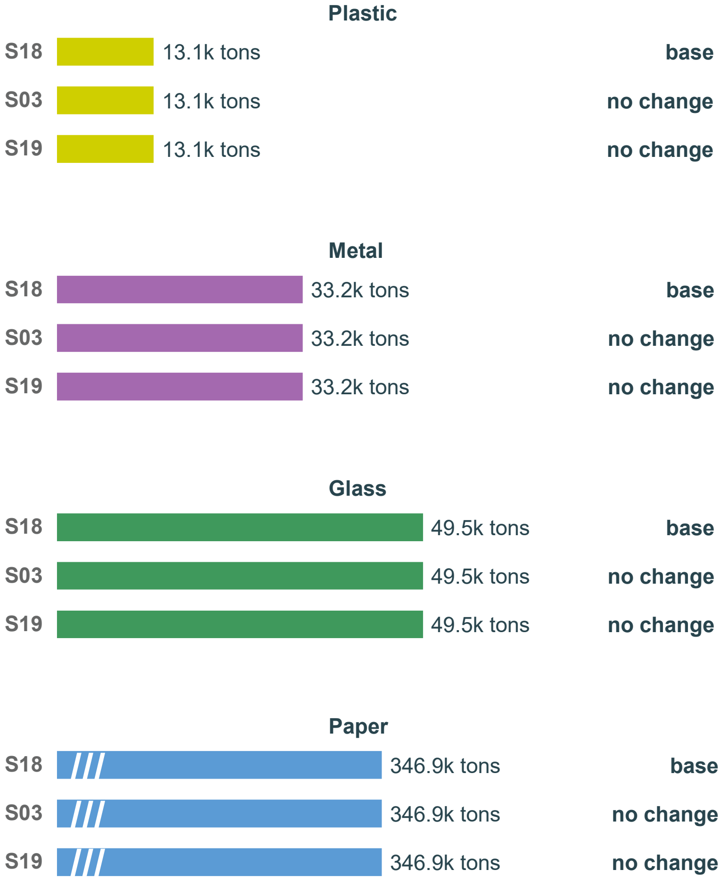
S18, S03, S19 – Recovery by Material Comparison

TOTAL MATERIALS PROPERLY MARKETED
(in thousands of tons)



Paper chart starts at 250k tons

This comparison illustrates:

Impact of changing the types of trucks used to collect on-route glass

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

No changes. The only difference is in the type of trucks used to collect the glass on-route.

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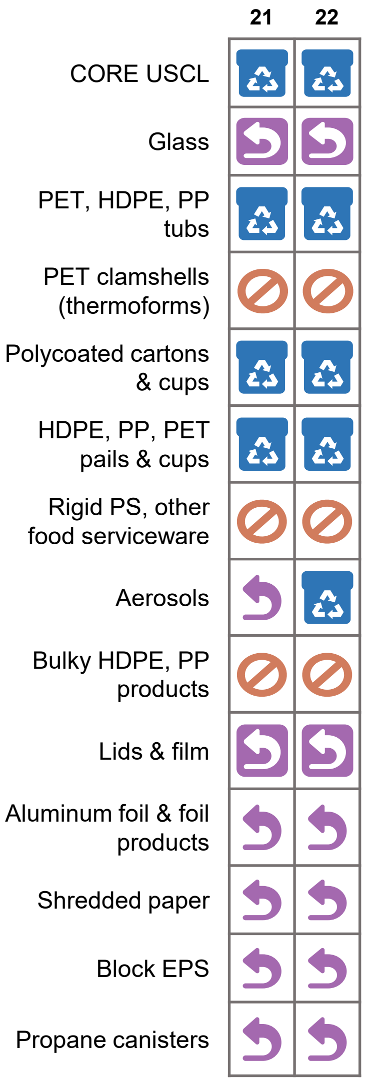
S21, S22 – Cost Comparison



This comparison illustrates:

Impact of shifting empty aerosol can collection from PRO depots to the USCL

USCL
Add aerosols

Glass
No change

PRO Depots
Exist, remove aerosols

Tons that change
Metal

WHAT HAPPENS TO COSTS?

Net costs increase by less than 0.2% (less than $1M). These differences are very small compared to the level of uncertainty in the costs.

Both scenarios include draining the aerosols to manage the contents safely, but S22 also includes sorting them from other materials. Both scenarios also include an unders recovery system to capture and properly recycle more small items that would otherwise be lost to residuals.

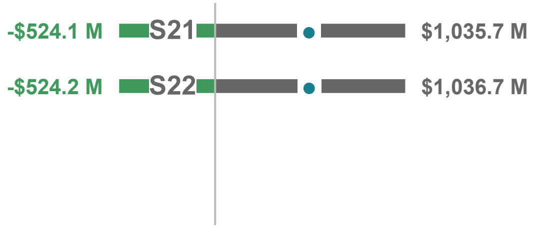
Analysis of both scenarios does not include the potential costs of a high-impact release such as a fire or worker exposure. Risks of such a costly event are perceived to be higher in S22 because of greater likelihood of a release inside a MRF.

In addition, S21 allows for better control of any contents remaining inside collected aerosols. In S22, aerosols recovered in a MRF may flow into a scrap metal bale, sent to a scrap metal yard and then shredded, potentially releasing contents to the environment. Indirect costs from such releases are also not included in the evaluation of S22.

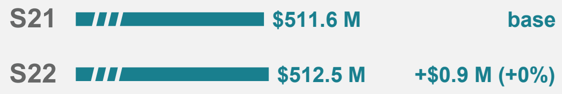
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs

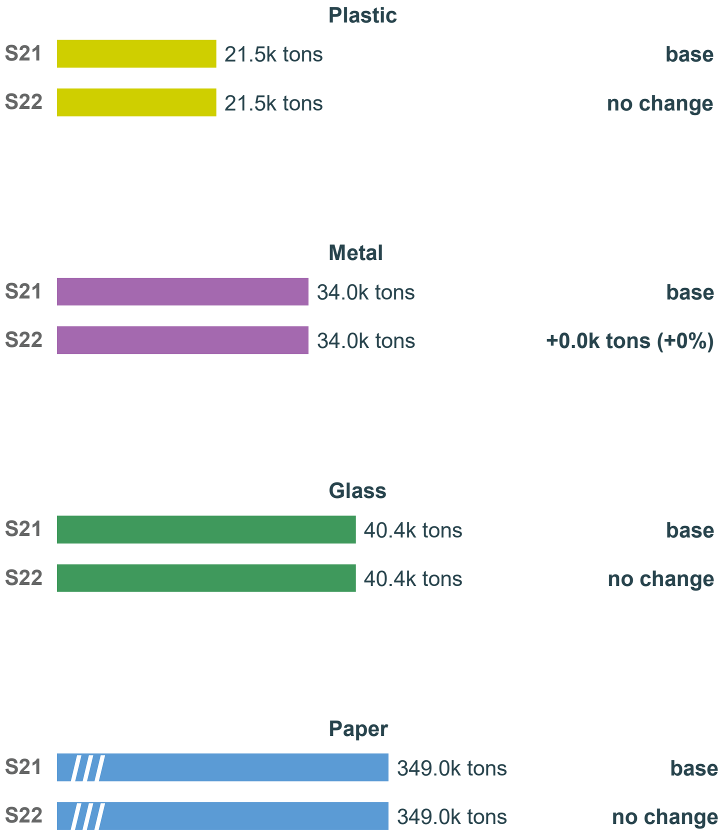


Net costs chart starts at $475 M

CASCADIA CONSULTING GROUP
Bell & Associates
Circular Matters

S21, S22 – Recovery by Material Comparison

TOTAL MATERIALS PROPERLY MARKETED
(in thousands of tons)



Paper chart starts at 250k tons

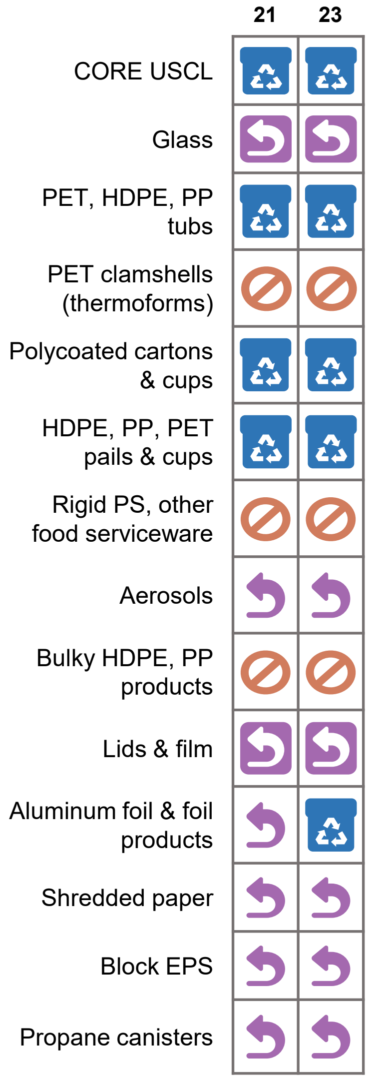
This comparison illustrates:

Impact of shifting empty aerosol can collection from PRO depots to the USCL

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

Metal tons properly recycled increase slightly (less than 50 tons). Aerosols are assumed to make up a very small part of metal can generation. The increased convenience of curbside collection is somewhat offset by losses at the MRF during sortation.

S21, S23 – Cost Comparison



This comparison illustrates:

Impact of shifting aluminum foil products collection from PRO depots to the USCL

USCL
Add aluminum foil and foil products

Glass
No change

PRO Depots
Exist, remove aluminum foil and foil products

Tons that change
Metal

WHAT HAPPENS TO COSTS?

Net costs increase by less than 0.1% (less than $0.5M). The slight increase in direct costs is almost entirely offset by the additional savings in indirect costs. These differences are very small compared to the level of uncertainty in the costs.

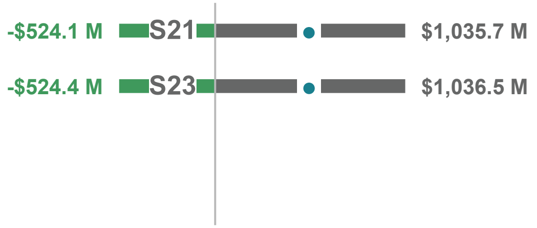
Both scenarios assume that the aluminum foil and foil products will be marketed to a specialized aluminum smelter that is designed to recover a higher percentage of material. In most aluminum furnaces, foil and foil products suffer high rates of yield loss. Oregon MRFs at present typically co-market aluminum foil with cans, resulting in very little recovery of aluminum and resulting environmental benefits. S23 includes additional costs associated with separation of aluminum foil from cans inside the MRF.

Both scenarios also include an unders recovery system to capture and properly recycle more small items that would otherwise be lost to the residual stream, including foil.

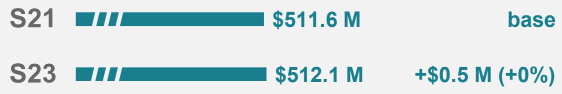
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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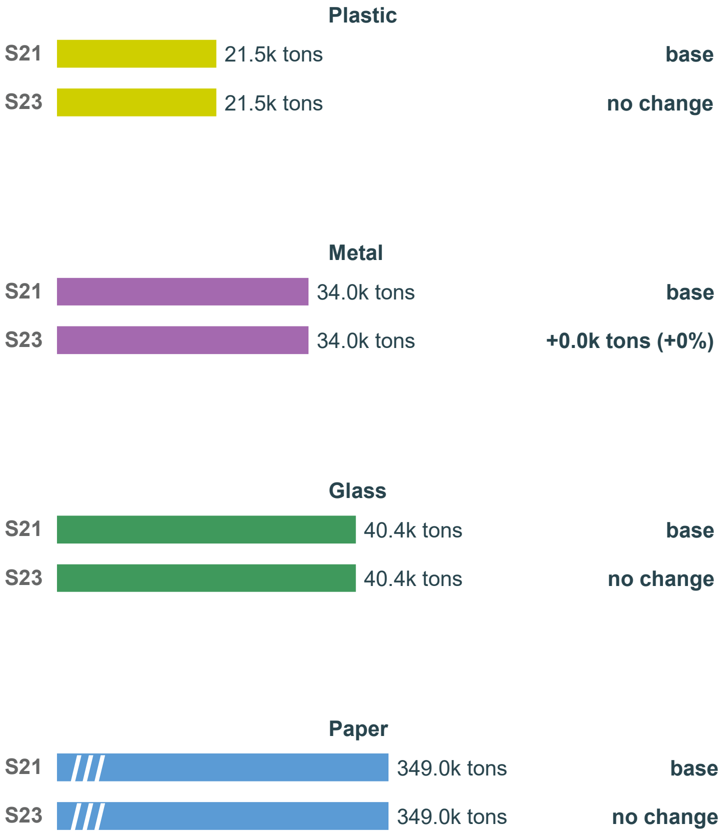
S21, S23 – Recovery by Material Comparison

TOTAL MATERIALS PROPERLY MARKETED
(in thousands of tons)



Paper chart starts at 250k tons

This comparison illustrates:

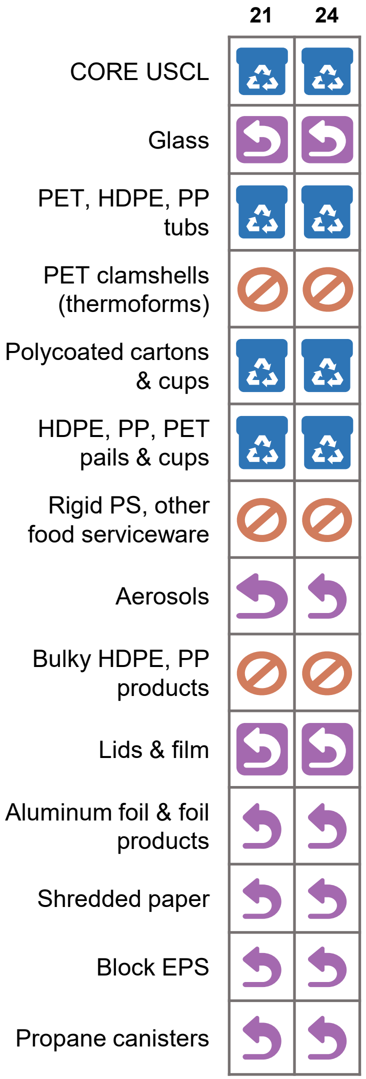
Impact of shifting aluminum foil and foil products collection from PRO depots to the USCL

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

Metal tons properly recycled increase slightly (about 50 tons). Aluminum foil and foil products are assumed to make up a very small part of metal generation. The increased convenience of curbside collection is somewhat offset by losses at the MRF during sortation.

Foil and pressed foil products are often used for food. Although not modeled or researched, it's possible that adding these products to the USCL may increase inbound contamination slightly due to food stuck to the materials.

S21, S24 – Cost Comparison



This comparison illustrates:

Impact of changing the types of depots assumed in PRO depot collection

USCL	Glass	PRO Depots	Tons that change
No change	No change	Exist, change type	None

WHAT HAPPENS TO COSTS?

Both S21 and S24 accept the same materials in the USCL and at PRO depots. They differ only in the types of PRO depots used. Compared to S21, S24 has fewer multi-material PRO depots that accept the full range of depot materials and more collection points that are return-to-retail or single-material depots. The differences are largest in Grouping 1 (Metro) and Grouping 2 (Willamette Valley and other areas with curbside recycling near Metro).

Net costs are modeled to be about 1.2% ($6.3M) lower in S24 compared to S21, due to both direct and indirect costs. These differences are small compared to the level of uncertainty in the costs.

Direct costs are modeled as lower for two main reasons. First, the capital, staffing, and operating costs of each return-to-retail site (assumed to be small and located inside an existing store) and single-material depot (also assumed to be small and located in the parking lot of an existing business) are estimated to be smaller than the estimated costs of a full-service multi-material depot. The multi-material depots are assumed to require a dedicated building and be fully staffed.

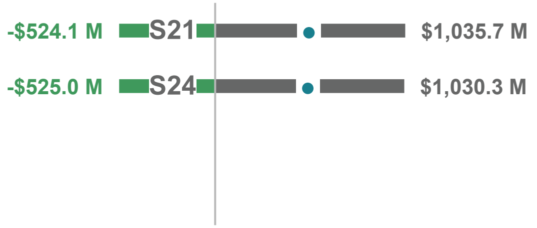
Second, PRO depot users are modeled as driving fewer extra miles in S24, when they are assumed to be combining recycling with a trip they would already take to a retailer, than in S21, when they are assumed to be making a special trip to the PRO depot.

The savings from indirect costs are slightly greater in S24 due to the decreased driving by PRO depot users.

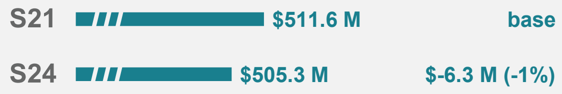
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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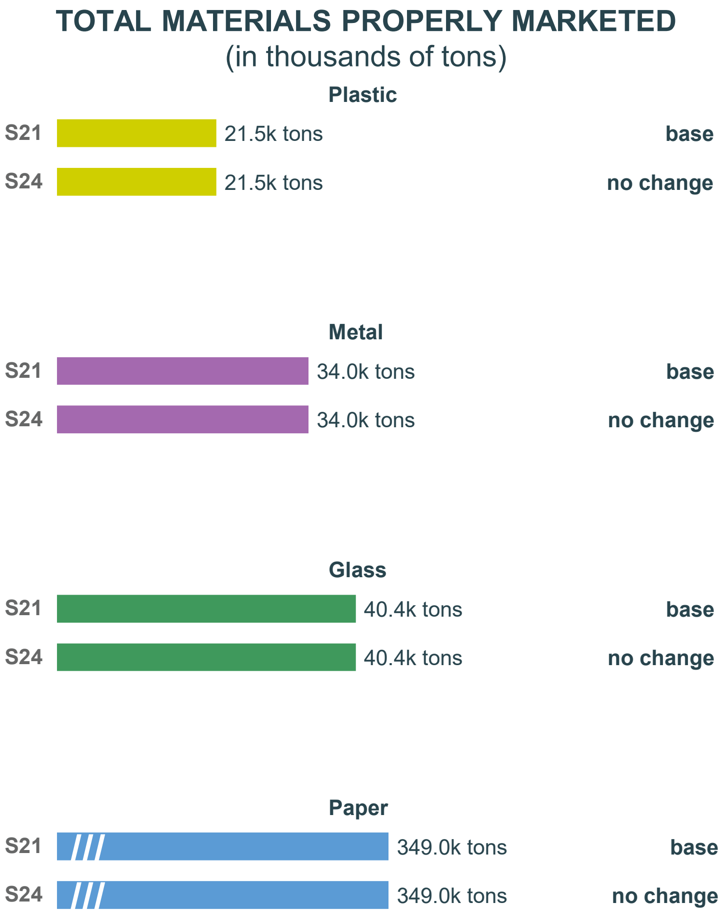
S21, S24 – Recovery by Material Comparison



Paper chart starts at 250k tons

This comparison illustrates:

Impact of changing the types of depots assumed in PRO depot collection

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

No change in tons because only the type of depots change, not the number of collection points or materials accepted.

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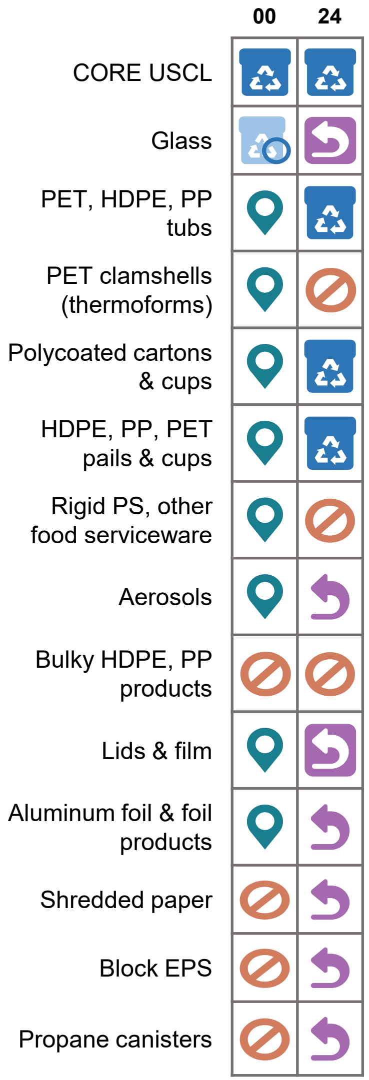
S00, S24 – Cost Comparison



This comparison illustrates:

Impact of modernizing the recycling system with the USCL, contamination reduction education, PRO depots, and modernized MRFs

USCL
Created to standardize the accepted list statewide

Glass
Switches to PRO depots statewide

PRO Depots
Added to increase materials accepted statewide

Tons that change
Plastic, metal, glass, paper

WHAT HAPPENS TO COSTS?

S00 represents the current acceptance lists and recycling system, with costs and tons increased only to reflect projected population growth. S24 represents the modernized recycling system with a statewide commingled recycling list, additional materials accepted at PRO depots, and reduced contamination in both collected and marketed recyclable materials.

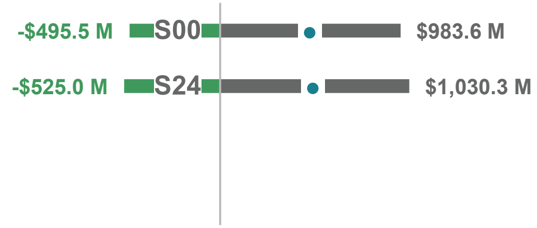
Net costs in S24 are modeled to be about 3.5% higher compared to S00. About 63% of the modeled increase in direct costs are offset by greater savings in indirect costs. However, these savings in indirect costs do not fully quantify the benefits of modernizing the recycling system. Unquantified benefits include:

- Greater system resilience, access to end markets and potentially higher revenue due to less contamination in outbound bales
- Reduced potential for bale contaminants to end up in marine debris or burning of plastics due to both less contamination and verified end markets
- Greater public confidence in recycling

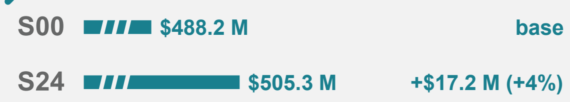
TOTAL COSTS BY SCENARIO

■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



A Closer Look: Net Costs



Net costs chart starts at $475 M

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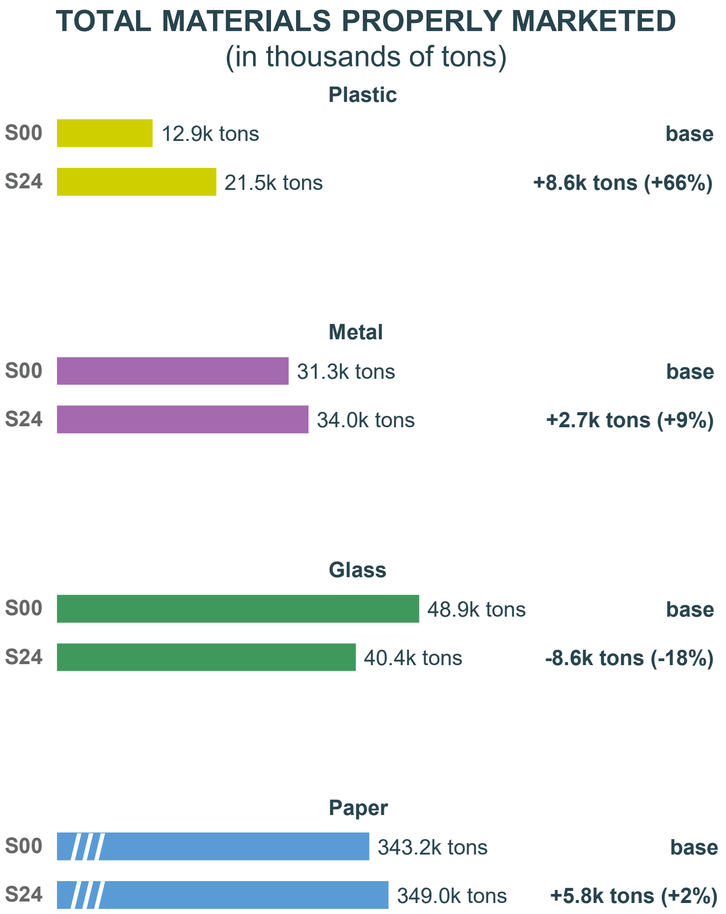
S00, S24 – Recovery by Material Comparison



Paper chart starts at 250k tons

This comparison illustrates:

Impact of modernizing the recycling system with the USCL, contamination reduction education, PRO depots, and modernized MRFs

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

The USCL, network of PRO depots, and modernized MRFs increase tons of properly marketed plastic, metal, and paper. However, shifting glass from on-route to PRO-depot only collection reduces tons recycled.

Plastic tons properly marketed increase by nearly two-thirds (65%). The largest tonnage gains come from expanding recycling access to materials like polyethylene (PE) film, polypropylene (PP) and high-density polyethylene (HDPE) bulky items and large pails/tubs, other PP packaging, lids and caps, block EPS, and PET tubs and jars.

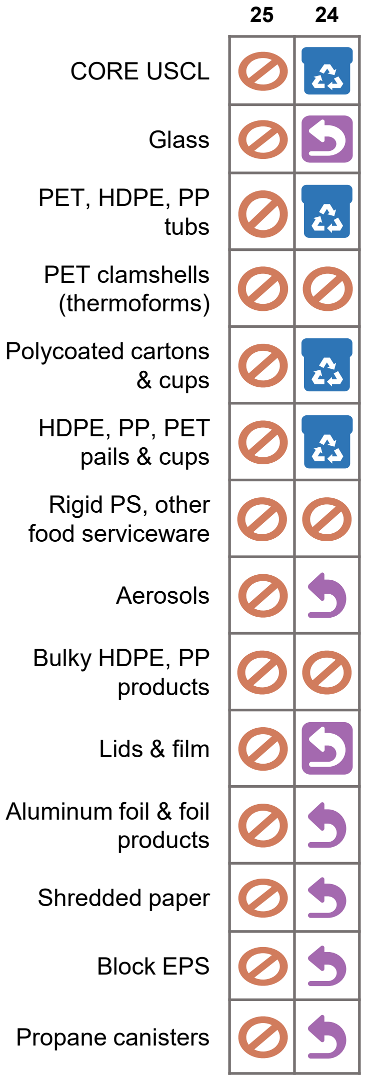
Metal tons properly marketed increase by 8%. About half of the tonnage gains come from making “other steel accepted at curbside” a core USCL material, which expands commingled collection outside of Metro.

Glass tons collected and properly marketed decreases by 18% because glass is taken off-route, and depot collection is not as convenient as on-route collection.

Paper tons properly recycled increases by 2%. The largest tonnage gains are in cardboard and printing and writing paper, as modernized MRFs capture more of these materials. Shredded paper (PRO depots) and polycoated cartons and cups (USCL) also increase as these materials become accepted statewide.

In addition, S24 (like all alternative scenarios S01-S25) has improved outbound bale quality compared to S00, so net costs may be lower than modeled here if Oregon MRFs receive a premium price for bales. Further, Oregon MRFs may retain better access to markets during future downturns by offering higher quality bales.

S25, S24 – Cost Comparison



This comparison illustrates:

Impact of recycling versus no recycling

USCL	Glass	PRO Depots	Tons that change
Recycling starts	Recycling starts	Added	Plastic, metal, glass, paper

WHAT HAPPENS TO COSTS?

Net costs are substantially lower with recycling than without recycling.

Without recycling, direct costs for a garbage-only system are estimated to be approximately $984M. Direct costs are lower from not operating separate recycling trucks, recycling areas at solid waste facilities, or MRFs. Garbage collection costs are higher because garbage tons increase, but per-ton tip fees are slightly lower, in Grouping 1 (Metro) and Grouping 2 (Willamette Valley and other areas with recycling near Metro) because in scenarios involving recycling, a portion of tip fees are used to support recycling education and programs.

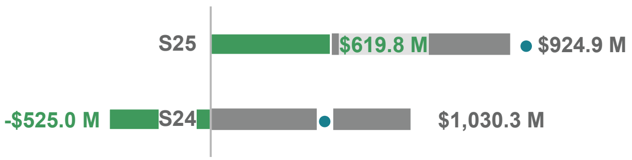
The modeled modernized recycling system in S24 has direct costs that are higher by $105M, for a total estimated direct cost of $1,030M).

However, the increase in indirect costs is more than ten times higher than the decrease in direct costs. With recycling, indirect costs are negative (providing a savings of nearly $525M) because of the social and environmental benefits of recycling. Without recycling, the indirect costs are positive (further increasing costs by nearly $620 M) because of the harmful impacts of disposal and lack of mitigating benefits from recycling.

TOTAL COSTS BY SCENARIO

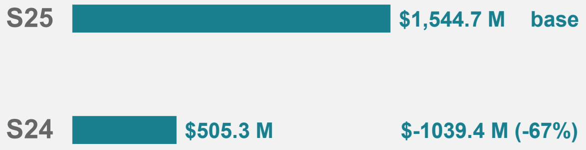
■ Indirect costs (benefits)
● Net costs (direct costs + indirect costs)
■ Direct costs (incl. commodity revenues)

Overall Costs Across Scenarios



The axis on this chart are a different scale than on all other comparison slides

A Closer Look: Net Costs



Net costs chart starts at $0 M and ends at $2500 M. On all other comparison slides, the chart starts at $475 M ends at $550 M.

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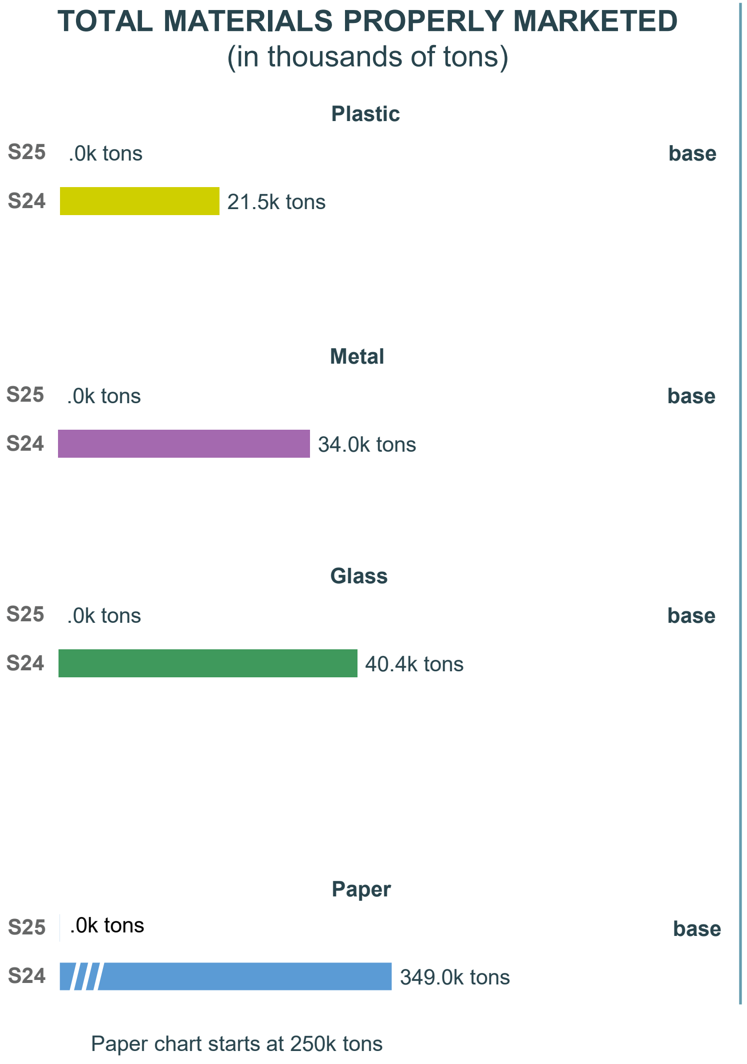
S25, S24 – Recovery by Material Comparison



This comparison illustrates:

Impact of recycling versus no recycling

WHAT HAPPENS TO TONS PROPERLY RECYCLED?

As you may expect, tons properly recycled increase for all materials when recycling exists.

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APPENDIX A. Scenario Profiles

March 14, 2023

Scenario 00 Profile

S00

CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

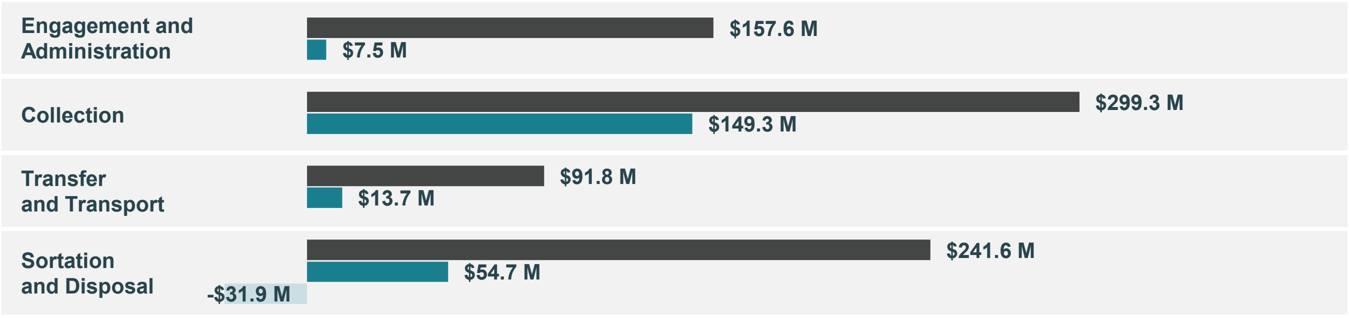
SCENARIO AT-A-GLANCE

Scenario 00 is the baseline scenario reflecting the current garbage and recycling system. It includes baseline levels of contamination in collected commingled recycling and in marketed materials after sorting. It has been expanded only to accommodate additional tons due to population growth and assumes no infrastructure or programmatic changes.

Tons Collected for Recycling all	545.9k
Tons Properly Recycled	485.2k
Inbound Contamination Rate	17.58%
Outbound Bale Contamination Rate	4.63%
Statewide Direct Cost	$983.6 M
Statewide Indirect Cost	-$495.5 M
Statewide Net Cost	$488.2 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$291
Net Cost Per Ton Generated	$145

TOTAL DIRECT COST (by stream and phase)

■ Garbage stream ■ Recycling stream ■ Commodity sales

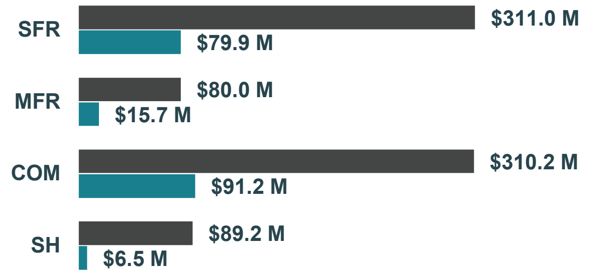


Total market/direct cost of garbage: $790.4 M

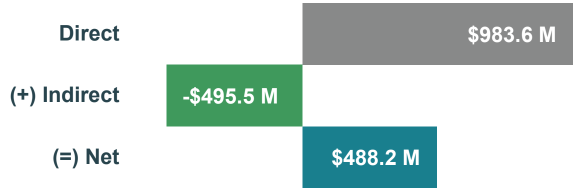
Total market/direct cost of recycling (net commodity sales): $193.3 M

TOTAL DIRECT COST (by stream and sector)

■ Garbage stream ■ Recycling stream + sales



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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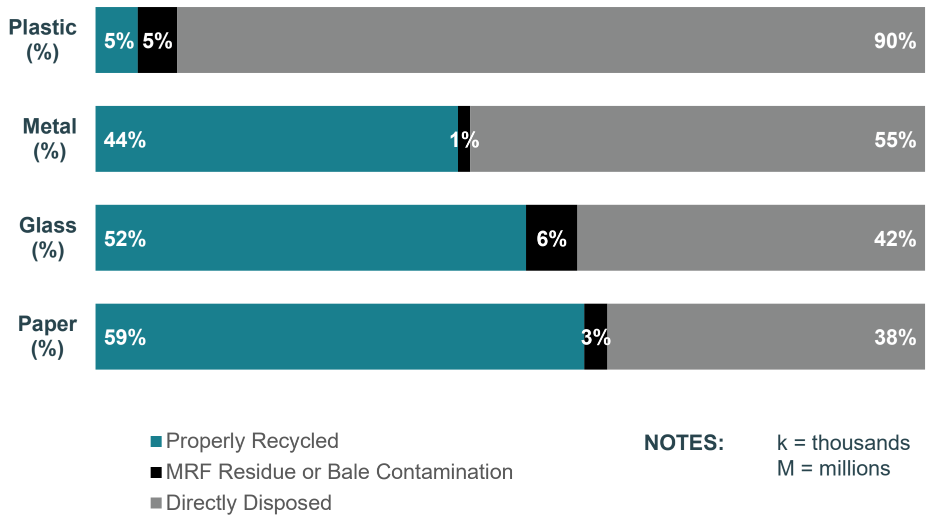
Scenario 00 Profile

S00

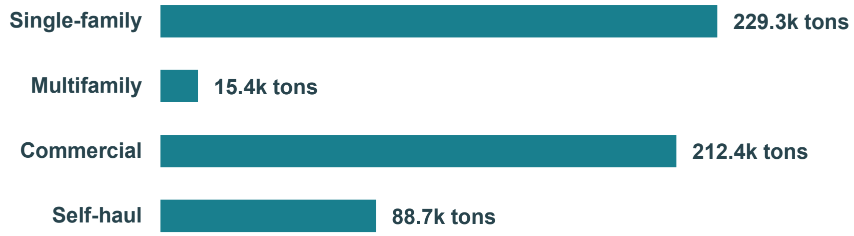
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

545.9 thousand tons collected for recycling



436.4 thousand tons properly recycled by material category

What happened to the rest of the material?

- 12.2 thousand tons were outbound bale contamination
- 48.4 thousand tons disposed as MRF residue
- 48.8 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

Scenario 01 Profile

S01

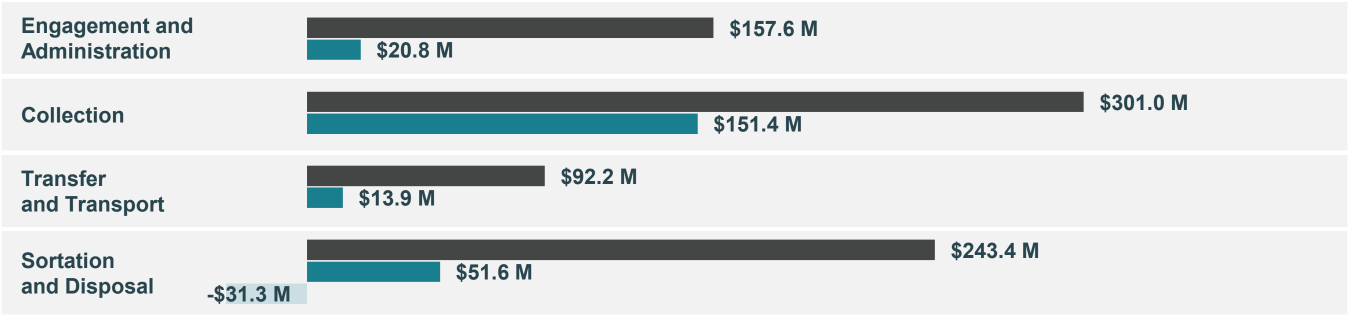
CORE USCL	♻
Glass	♻
PET, HDPE, PP tubs	⊘
PET clamshells (thermoforms)	⊘
Polycoated cartons & cups	⊘
HDPE, PP, PET pails & cups	⊘
Rigid PS, other food serviceware	⊘
Aerosols	⊘
Bulky HDPE, PP products	⊘
Lids & film	⊘
Aluminum foil & foil products	⊘
Shredded paper	⊘
Block EPS	⊘
Propane canisters	⊘

SCENARIO AT-A-GLANCE

Scenario 01 has the shortest USCL list, with only core USCL materials. Like all alternative scenarios except S25, S01 includes a new CRF (container recovery facility) line in order to achieve DEQ's sortation efficiency and bale quality goals. Like all alternative scenarios except S25, 30% of customers in Grouping 4 gain on-route recycling. Glass continues to be collected at curbside and there are no PRO depots.

Tons Collected for Recycling	529.1k
Tons Properly Recycled	485.7k
Inbound Contamination Rate	10.34%
Outbound Bale Contamination Rate	1.91%
Statewide Direct Cost	$1,000.5 M
Statewide Indirect Cost	-$497.5 M
Statewide Net Cost	$503.0 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$296
Net Cost Per Ton Generated	$149

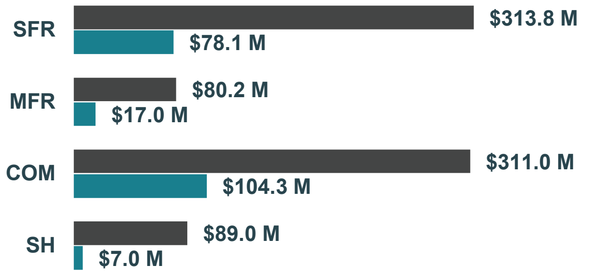
TOTAL DIRECT COST (by stream and phase)



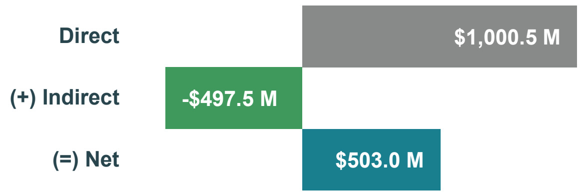
Total market/direct cost of garbage: $794.1 M

Total market/direct cost of recycling (net commodity sales): $206.4 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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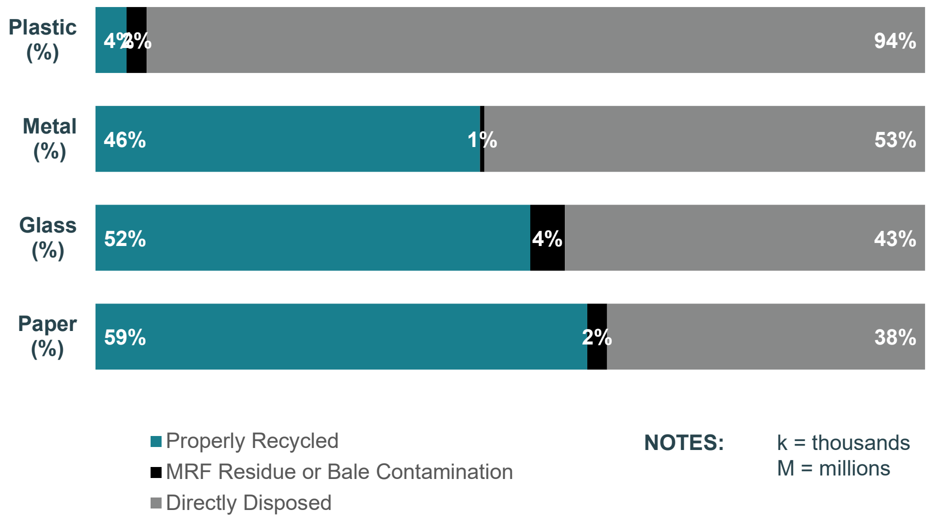
Scenario 01 Profile

S01

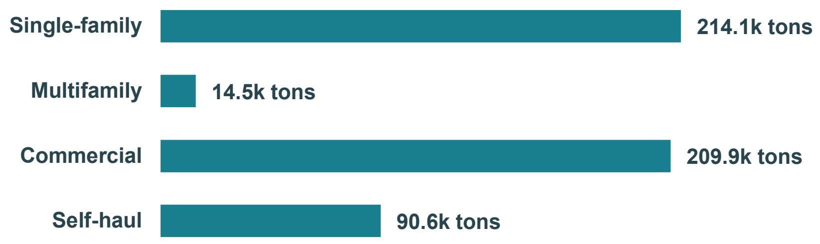
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

529.1 thousand tons collected for recycling



437.6 thousand tons properly recycled by material category

What happened to the rest of the material?

- 4.9 thousand tons were outbound bale contamination
- 38.5 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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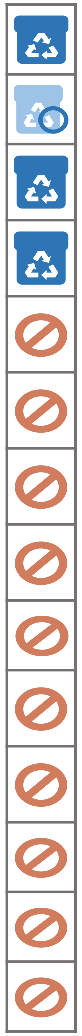
Scenario 02 Profile

S02

Material	Collected
CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

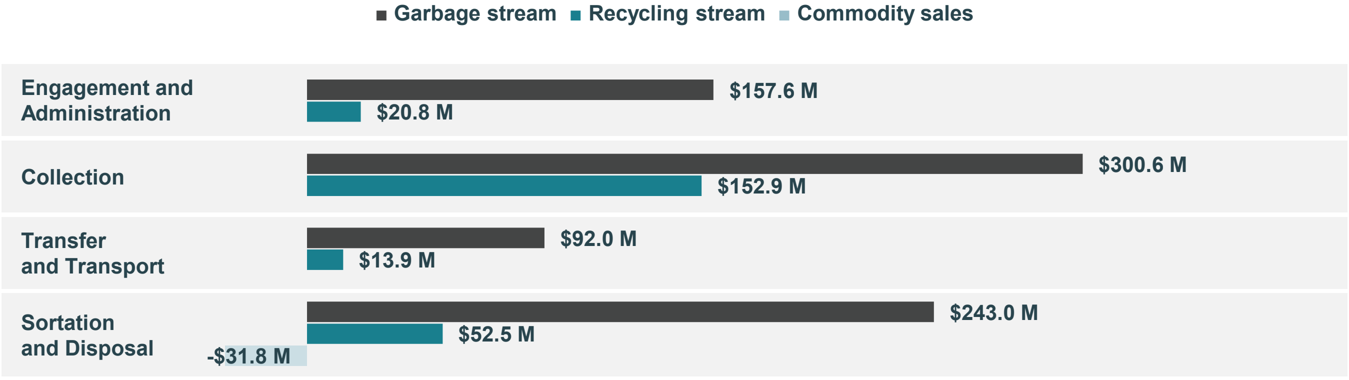


SCENARIO AT-A-GLANCE

Scenario 02 builds on S01 by adding more plastics to the USCL. Glass continues to be collected at curbside and there are no PRO depots.

Tons Collected for Recycling	533.4k
Tons Properly Recycled	489.2k
Inbound Contamination Rate	10.07%
Outbound Bale Contamination Rate	1.93%
Statewide Direct Cost	$1,001.6 M
Statewide Indirect Cost	-$500.4 M
Statewide Net Cost	$501.3 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$297
Net Cost Per Ton Generated	$149

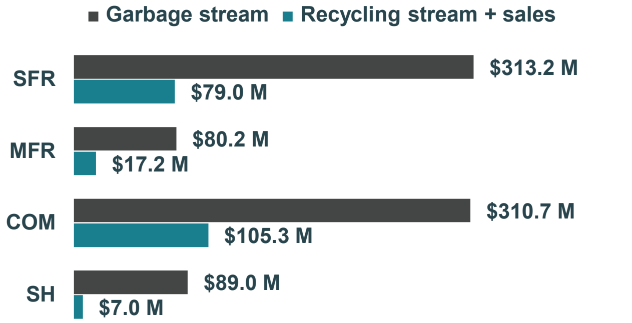
TOTAL DIRECT COST (by stream and phase)



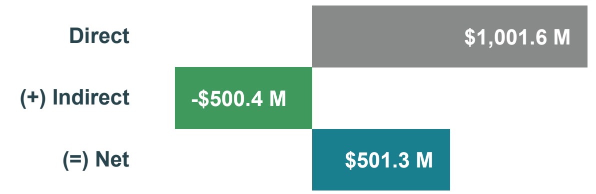
Total market/direct cost of garbage: $793.1 M

Total market/direct cost of recycling (net commodity sales): $208.5 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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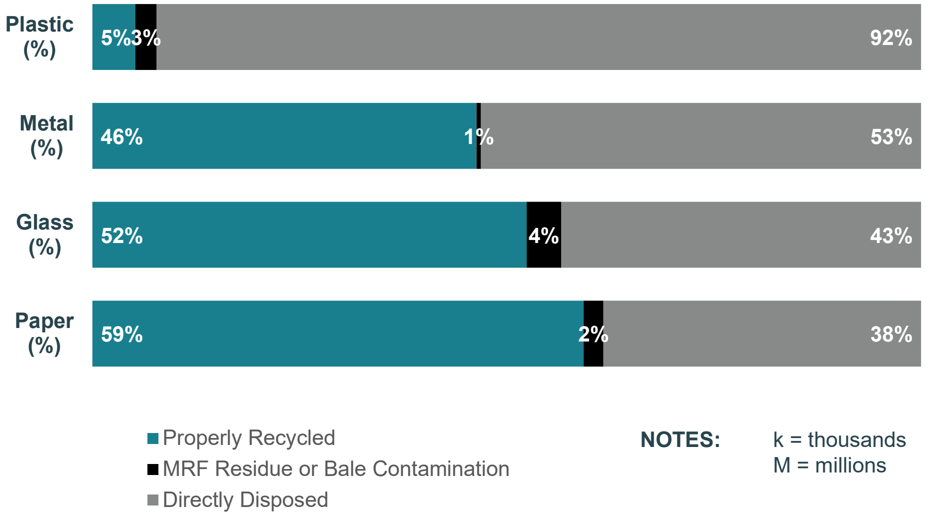
Scenario 02 Profile

S02

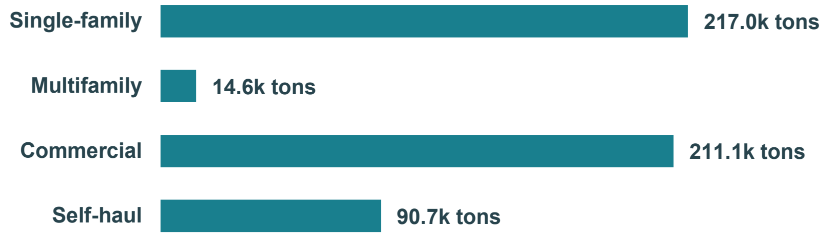
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

533.4 thousand tons collected for recycling



441.2 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.1 thousand tons were outbound bale contamination
- 39.1 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 03 Profile

S03

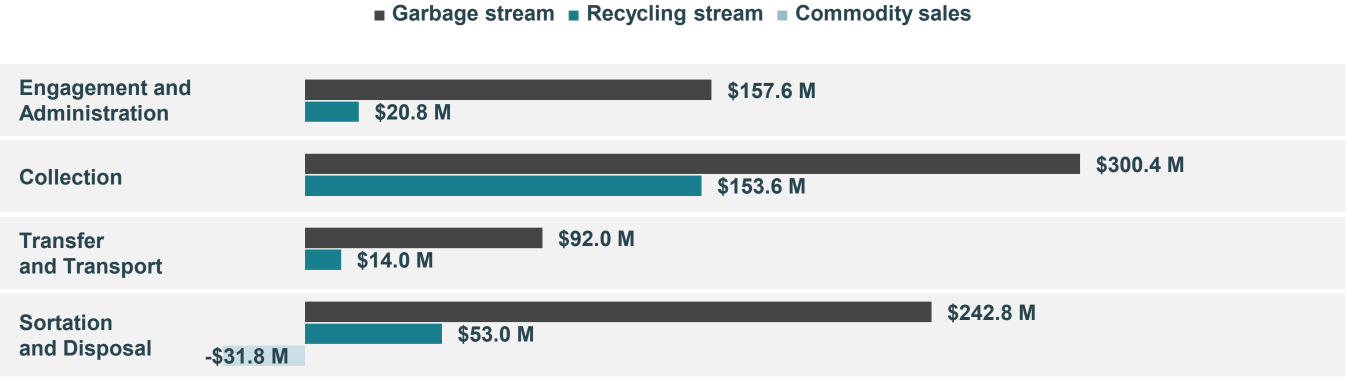
- CORE USCL
- Glass
- PET, HDPE, PP tubs
- PET clamshells (thermoforms)
- Polycoated cartons & cups
- HDPE, PP, PET pails & cups
- Rigid PS, other food serviceware
- Aerosols
- Bulky HDPE, PP products
- Lids & film
- Aluminum foil & foil products
- Shredded paper
- Block EPS
- Propane canisters

SCENARIO AT-A-GLANCE

Scenario 03 builds on S02 by adding polycoated cartons and cups to the USCL. The USCL for S03 is repeated in S04-S11 and S18-S20. Glass continues to be collected at curbside and there are no PRO depots.

Tons Collected for Recycling	535.1k
Tons Properly Recycled	490.7k
Inbound Contamination Rate	9.96%
Outbound Bale Contamination Rate	1.95%
Statewide Direct Cost	$1,002.4 M
Statewide Indirect Cost	-$503.2 M
Statewide Net Cost	$499.2 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$297
Net Cost Per Ton Generated	$148

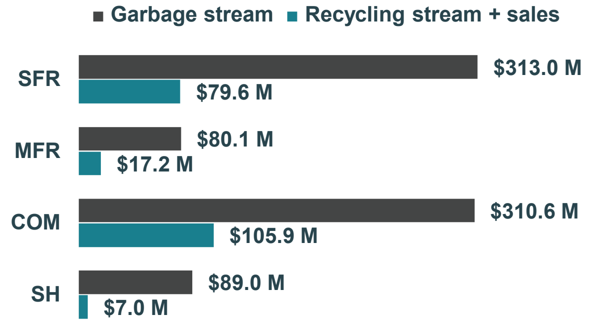
TOTAL DIRECT COST (by stream and phase)



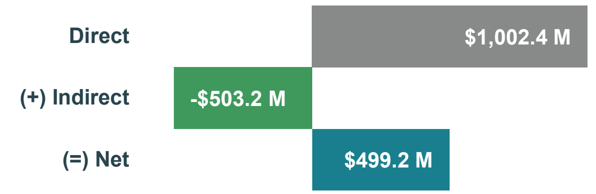
Total market/direct cost of garbage: $792.7 M

Total market/direct cost of recycling (net commodity sales): $209.7 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES:
SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul

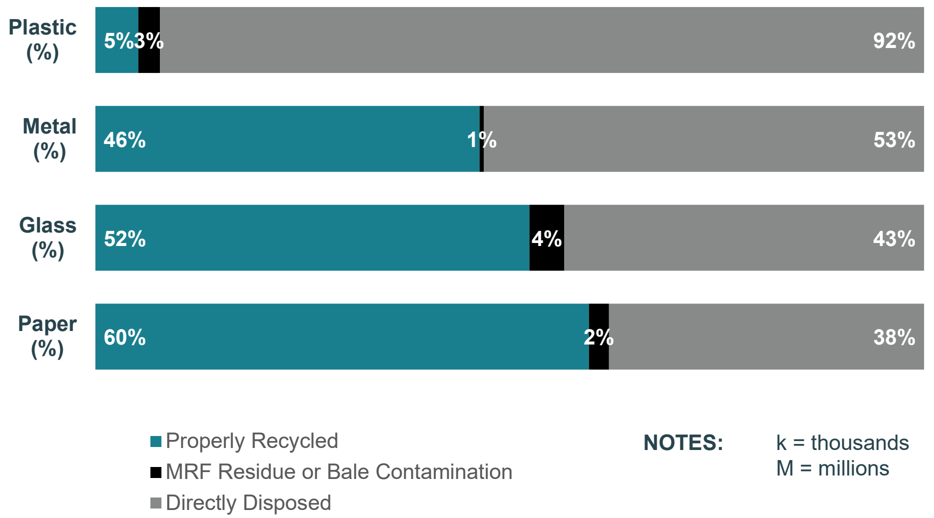
k = thousands
M = millions

Scenario 03 Profile

S03

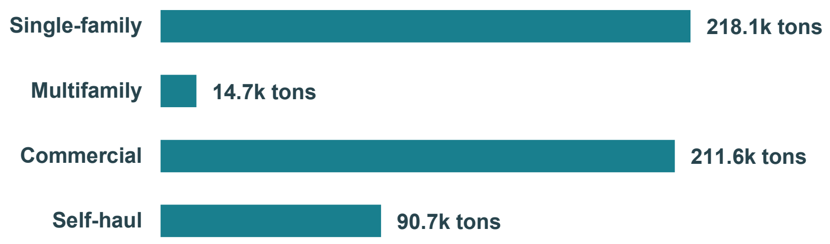
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

535.1 thousand tons collected for recycling



442.7 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.1 thousand tons were outbound bale contamination
- 39.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 04 Profile

S04

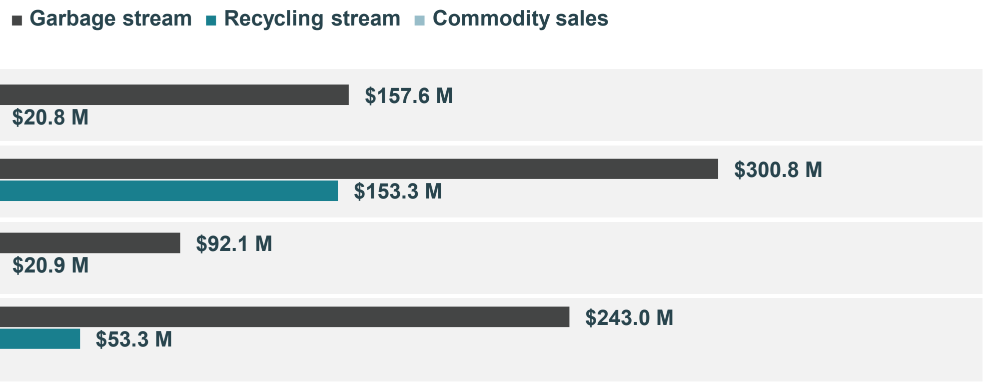
Material	
CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

SCENARIO AT-A-GLANCE

Scenario 04 uses the USCL from S03. Glass continues to be collected on-route in Metro but is collected at glass-only PRO depots elsewhere in the state.

Tons Collected for Recycling	531.7k
Tons Properly Recycled	486.3k
Inbound Contamination Rate	10.25%
Outbound Bale Contamination Rate	1.95%
Statewide Direct Cost	$1,010.0 M
Statewide Indirect Cost	-$501.5 M
Statewide Net Cost	$508.5 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$299
Net Cost Per Ton Generated	$151

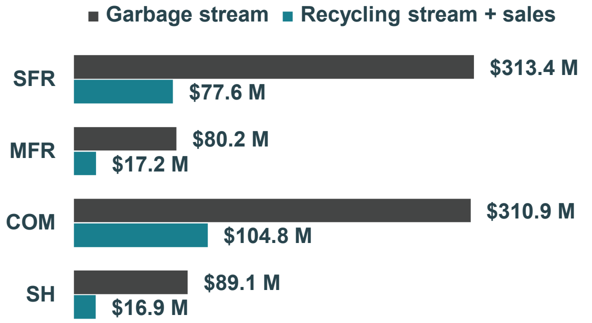
TOTAL DIRECT COST (by stream and phase)



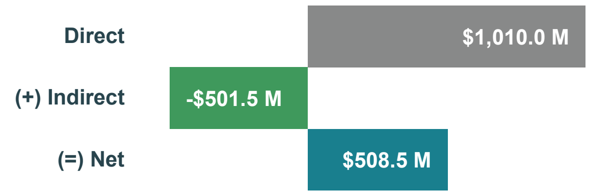
Total market/direct cost of garbage: $793.5 M

Total market/direct cost of recycling (net commodity sales): $216.5 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul
k = thousands
M = millions

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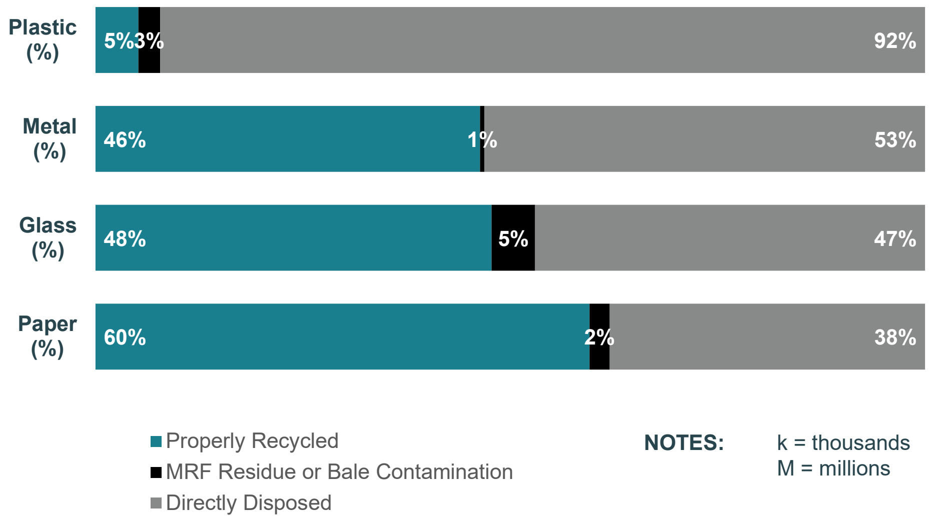
Scenario 04 Profile

S04

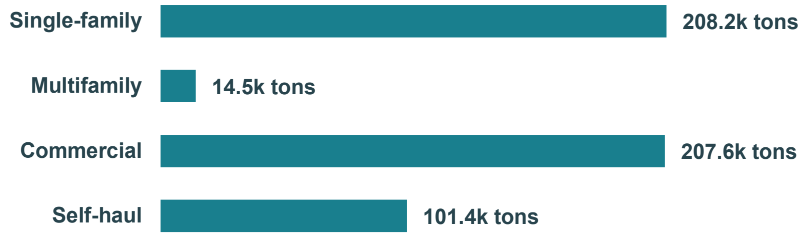
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

531.7 thousand tons collected for recycling



438.3 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.1 thousand tons were outbound bale contamination
- 40.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

Scenario 05 Profile

S05

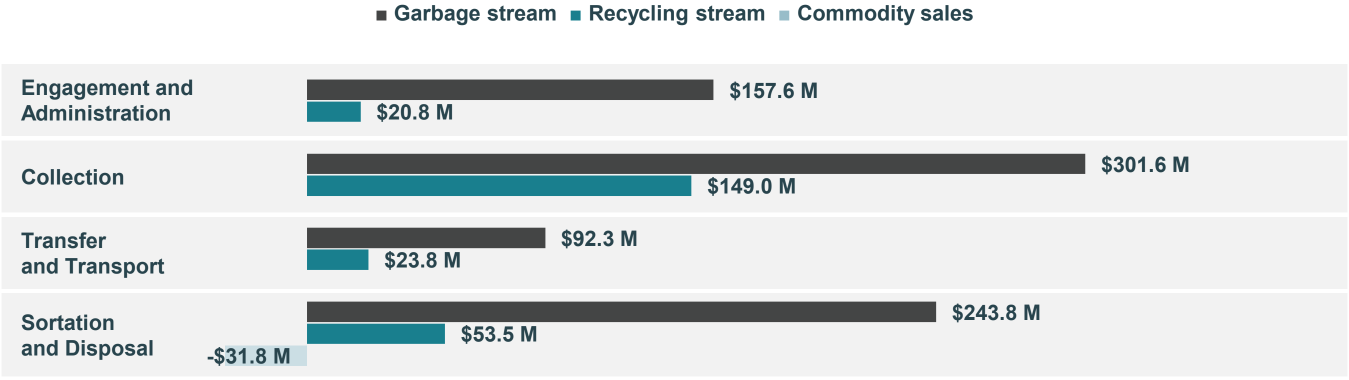
- CORE USCL
- Glass
- PET, HDPE, PP tubs
- PET clamshells (thermoforms)
- Polycoated cartons & cups
- HDPE, PP, PET pails & cups
- Rigid PS, other food serviceware
- Aerosols
- Bulky HDPE, PP products
- Lids & film
- Aluminum foil & foil products
- Shredded paper
- Block EPS
- Propane canisters

SCENARIO AT-A-GLANCE

Scenario 05 uses the USCL from S03. Glass is collected at glass-only PRO depots everywhere in the state.

Tons Collected for Recycling	524.4k
Tons Properly Recycled	477.9k
Inbound Contamination Rate	10.57%
Outbound Bale Contamination Rate	1.95%
Statewide Direct Cost	$1,010.7 M
Statewide Indirect Cost	-$502.8 M
Statewide Net Cost	$507.8 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$299
Net Cost Per Ton Generated	$150

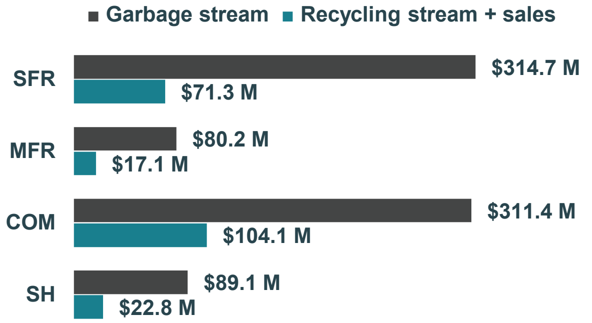
TOTAL DIRECT COST (by stream and phase)



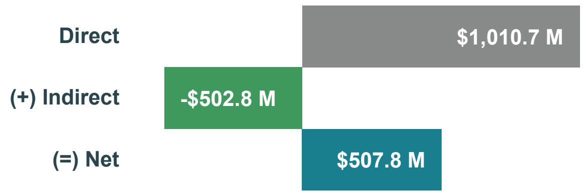
Total market/direct cost of garbage: $795.3 M

Total market/direct cost of recycling (net commodity sales): $215.3 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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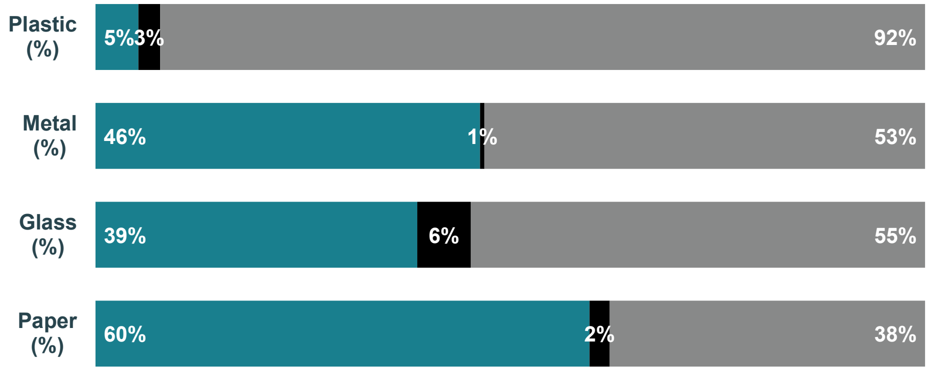
Scenario 05 Profile

S05

DISPOSITION OF ALL MATERIALS
(tonnage, overall)

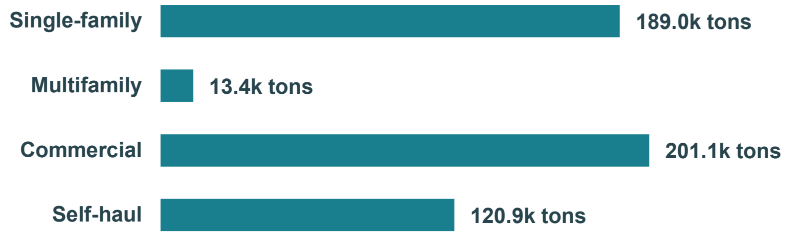
DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



■ Properly Recycled
■ MRF Residue or Bale Contamination
■ Directly Disposed

NOTES: k = thousands
M = millions

524.4 thousand tons collected for recycling



429.9 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.1 thousand tons were outbound bale contamination
- 41.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 06 Profile

S06

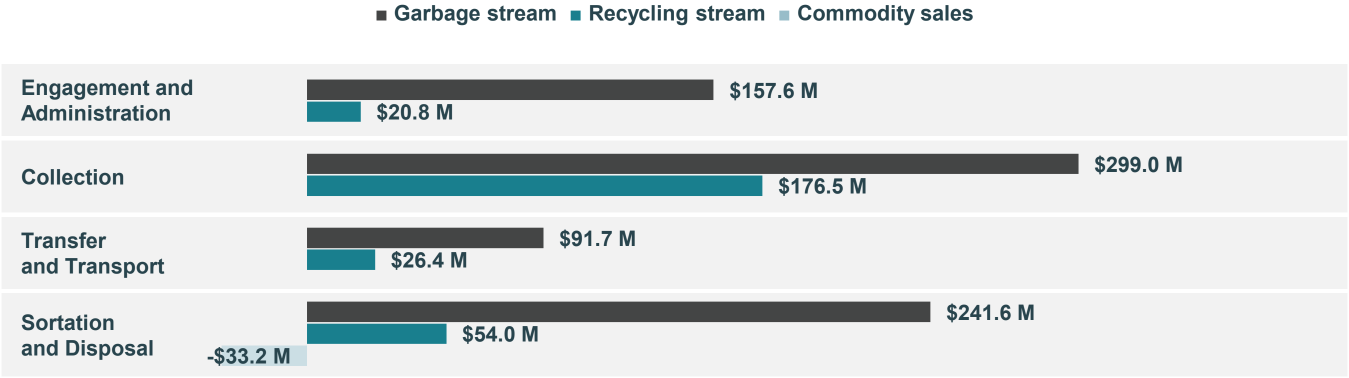
Material	
CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

SCENARIO AT-A-GLANCE

Scenario 06 uses the USCL from S03. Glass continues to be collected at curbside everywhere in the state. A medium number of PRO depots collect shredded paper, aerosol cans, aluminum foil, expanded polystyrene foam, plastic film, and additional plastic items.

Tons Collected for Recycling	548.1k
Tons Properly Recycled	502.5k
Inbound Contamination Rate	10.33%
Outbound Bale Contamination Rate	1.98%
Statewide Direct Cost	$1,034.3 M
Statewide Indirect Cost	-$519.1 M
Statewide Net Cost	$515.3 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$306
Net Cost Per Ton Generated	$153

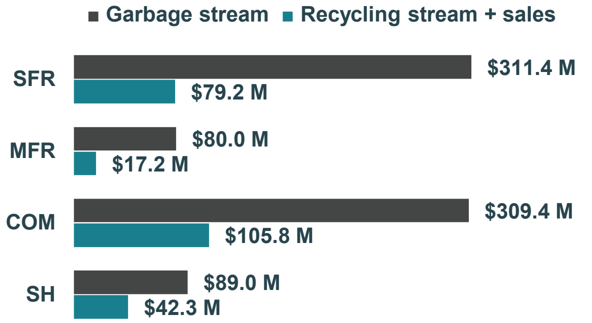
TOTAL DIRECT COST (by stream and phase)



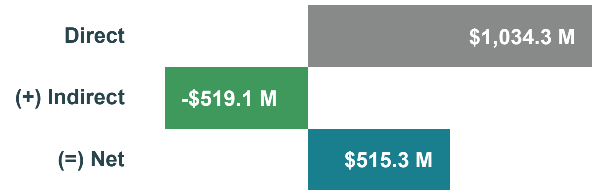
Total market/direct cost of garbage: $789.8 M

Total market/direct cost of recycling (net commodity sales): $244.5 M

TOTAL DIRECT COST
(by stream and sector)



TOTAL COST



NOTES:
SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul
k = thousands
M = millions

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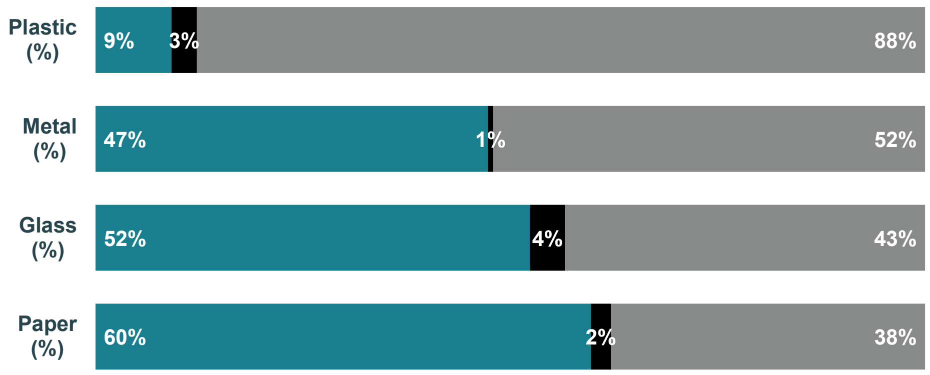
Scenario 06 Profile

S06

DISPOSITION OF ALL MATERIALS
(tonnage, overall)

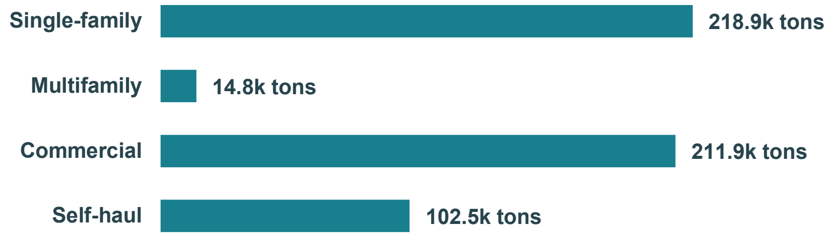
DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



■ Properly Recycled
■ MRF Residue or Bale Contamination
■ Directly Disposed

NOTES: k = thousands
M = millions

548.1 thousand tons collected for recycling



454.4 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 40.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 07 Profile

S07

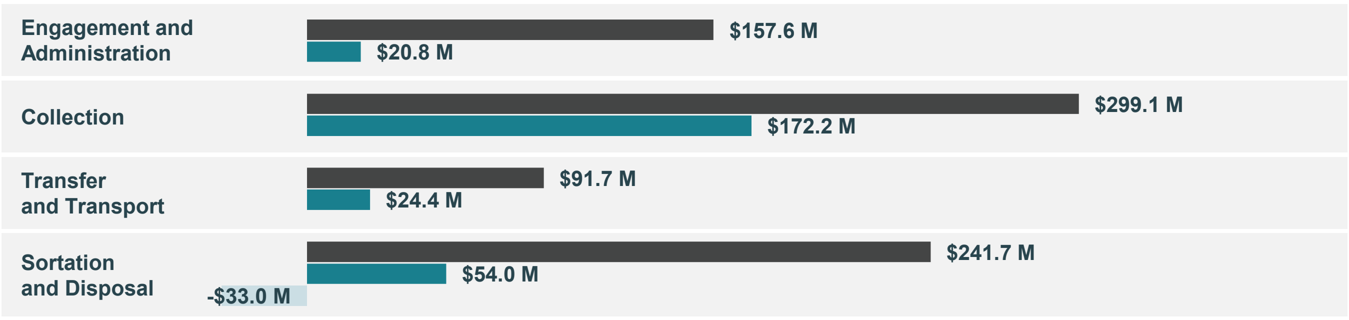
CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

SCENARIO AT-A-GLANCE

Scenario 07 uses the USCL from S03. Glass continues to be collected at curbside everywhere in the state. A lower number of PRO depots than S06 collect shredded paper, aerosol cans, aluminum foil, expanded polystyrene foam, plastic film, and additional plastic items.

Tons Collected for Recycling	546.9k
Tons Properly Recycled	501.3k
Inbound Contamination Rate	10.34%
Outbound Bale Contamination Rate	1.97%
Statewide Direct Cost	$1,028.5 M
Statewide Indirect Cost	-$517.8 M
Statewide Net Cost	$510.8 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$305
Net Cost Per Ton Generated	$151

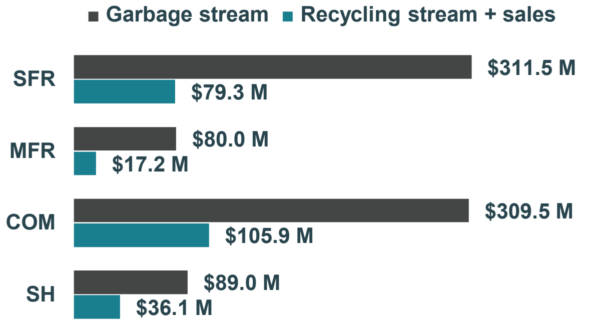
TOTAL DIRECT COST (by stream and phase)



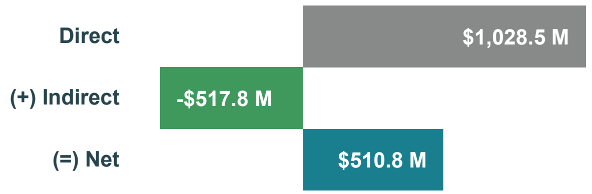
Total market/direct cost of garbage: $790.0 M

Total market/direct cost of recycling (net commodity sales): $238.5 M

TOTAL DIRECT COST
(by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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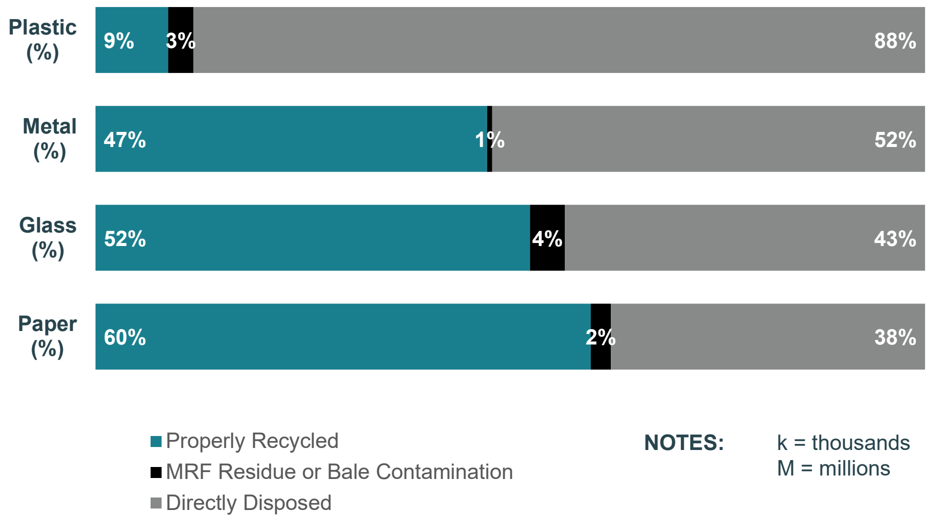
Scenario 07 Profile

S07

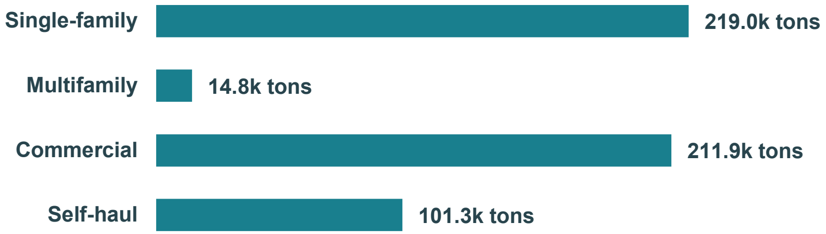
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

546.9 thousand tons collected for recycling



453.3 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 40.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

Scenario 08 Profile

S08

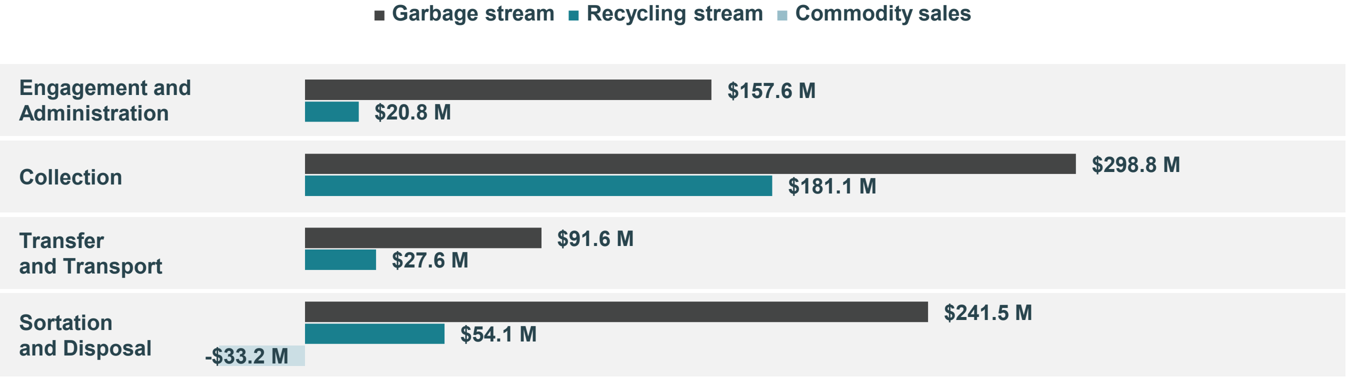
CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

SCENARIO AT-A-GLANCE

Scenario 08 uses the USCL from S03. Glass continues to be collected at curbside everywhere in the state. A higher number of PRO depots than S06 collect shredded paper, aerosol cans, aluminum foil, expanded polystyrene foam, plastic film, and additional plastic items.

Tons Collected for Recycling	549.3k
Tons Properly Recycled	503.7k
Inbound Contamination Rate	10.31%
Outbound Bale Contamination Rate	1.99%
Statewide Direct Cost	$1,039.8 M
Statewide Indirect Cost	-$520.7 M
Statewide Net Cost	$519.1 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$308
Net Cost Per Ton Generated	$154

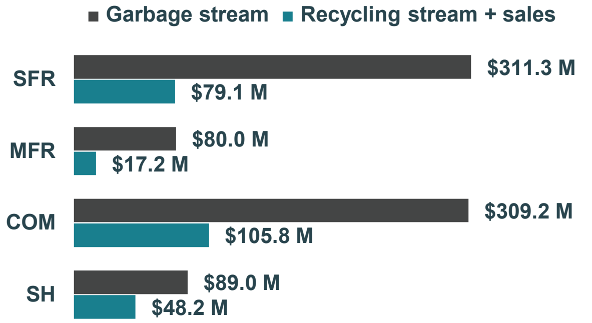
TOTAL DIRECT COST (by stream and phase)



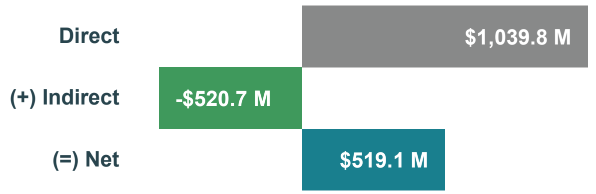
Total market/direct cost of garbage: $789.5 M

Total market/direct cost of recycling (net commodity sales): $250.4 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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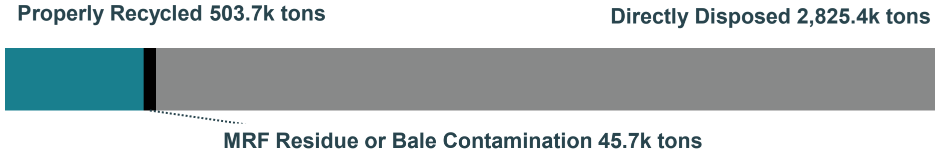
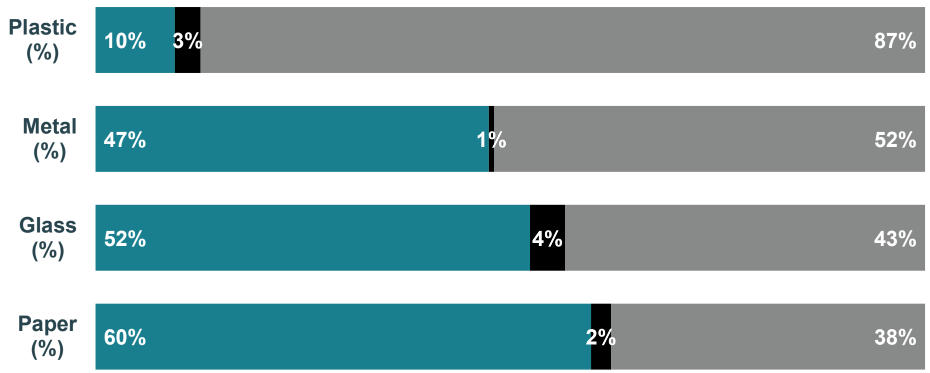
Scenario 08 Profile

S08

DISPOSITION OF ALL MATERIALS
(tonnage, overall)



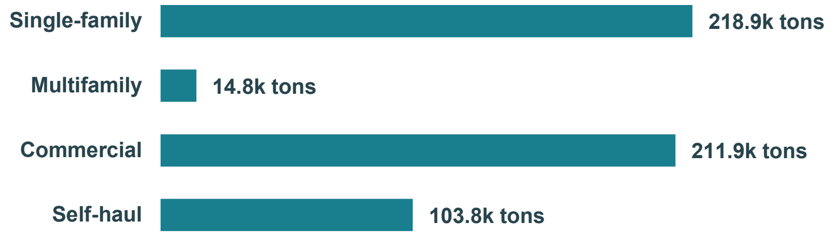
DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



■ Properly Recycled
■ MRF Residue or Bale Contamination
■ Directly Disposed

NOTES: k = thousands
M = millions

549.3 thousand tons collected for recycling



455.6 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 40.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

Scenario 09 Profile

S09

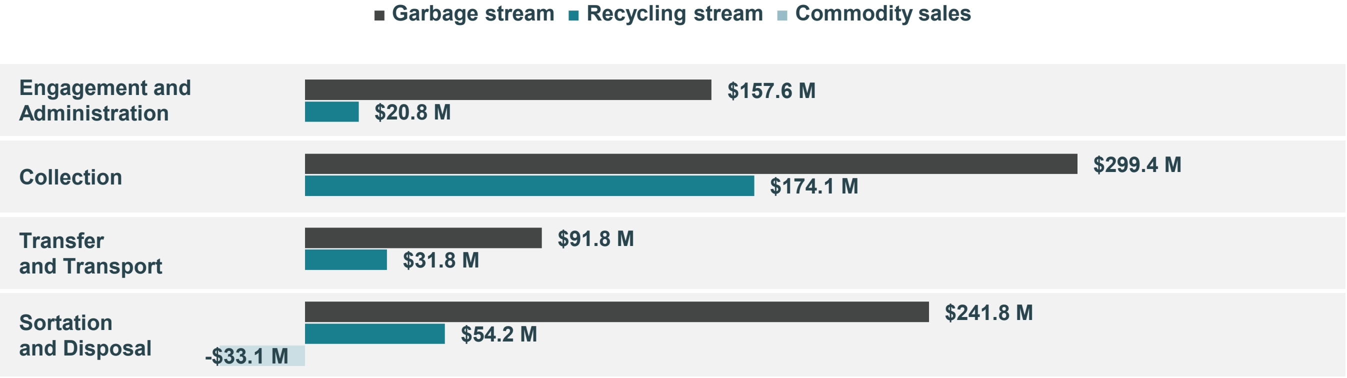
Material
CORE USCL
Glass
PET, HDPE, PP tubs
PET clamshells (thermoforms)
Polycoated cartons & cups
HDPE, PP, PET pails & cups
Rigid PS, other food serviceware
Aerosols
Bulky HDPE, PP products
Lids & film
Aluminum foil & foil products
Shredded paper
Block EPS
Propane canisters

SCENARIO AT-A-GLANCE

Scenario 09 uses the USCL from S03. A medium number of PRO depots collect shredded paper, aerosol cans, aluminum foil, expanded polystyrene foam, plastic film, and additional plastic items. Glass continues to be collected at curbside in Metro and is collected at PRO depots elsewhere in the state.

Tons Collected for Recycling	544.7k
Tons Properly Recycled	498.1k
Inbound Contamination Rate	10.62%
Outbound Bale Contamination Rate	1.98%
Statewide Direct Cost	$1,038.3 M
Statewide Indirect Cost	-$517.8 M
Statewide Net Cost	$520.5 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$308
Net Cost Per Ton Generated	$154

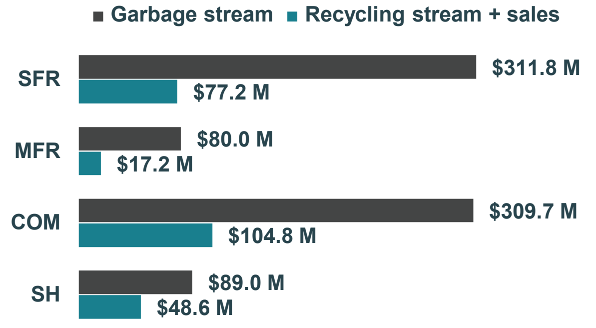
TOTAL DIRECT COST (by stream and phase)



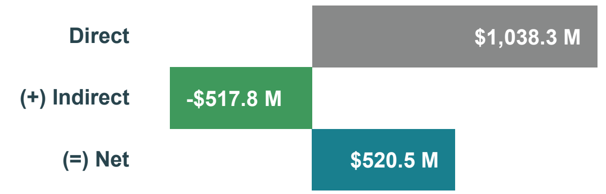
Total market/direct cost of garbage: $790.5 M

Total market/direct cost of recycling (net commodity sales): $247.8 M

TOTAL DIRECT COST
(by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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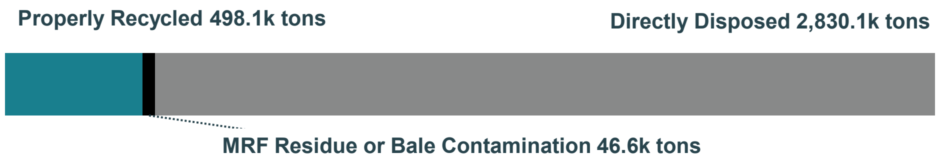
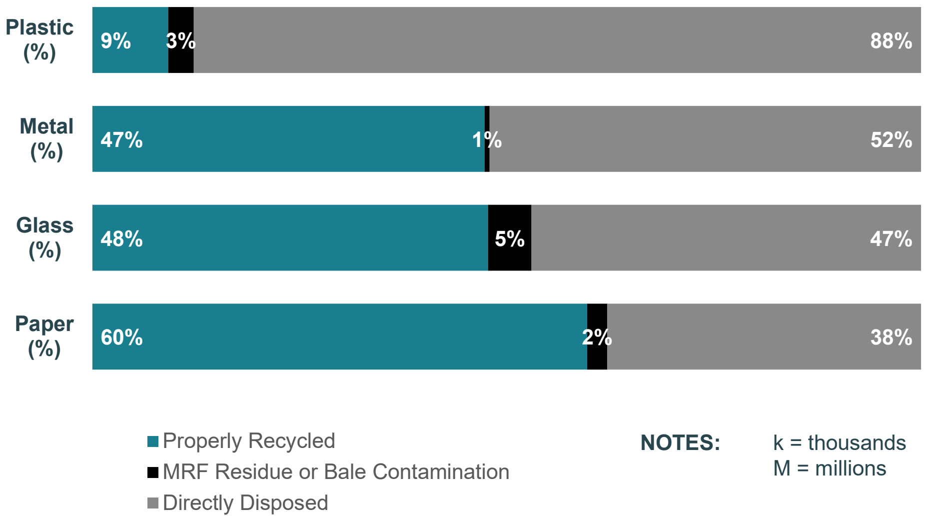
Scenario 09 Profile

S09

DISPOSITION OF ALL MATERIALS
(tonnage, overall)

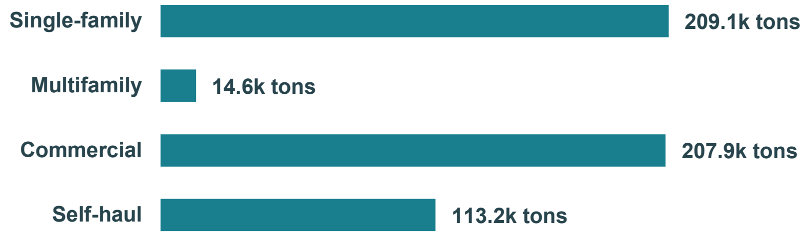


DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

544.7 thousand tons collected for recycling



450.0 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 41.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

Scenario 10 Profile

S10

CORE USCL

Glass

PET, HDPE, PP tubs

PET clamshells (thermoforms)

Polycoated cartons & cups

HDPE, PP, PET pails & cups

Rigid PS, other food serviceware

Aerosols

Bulky HDPE, PP products

Lids & film

Aluminum foil & foil products

Shredded paper

Block EPS

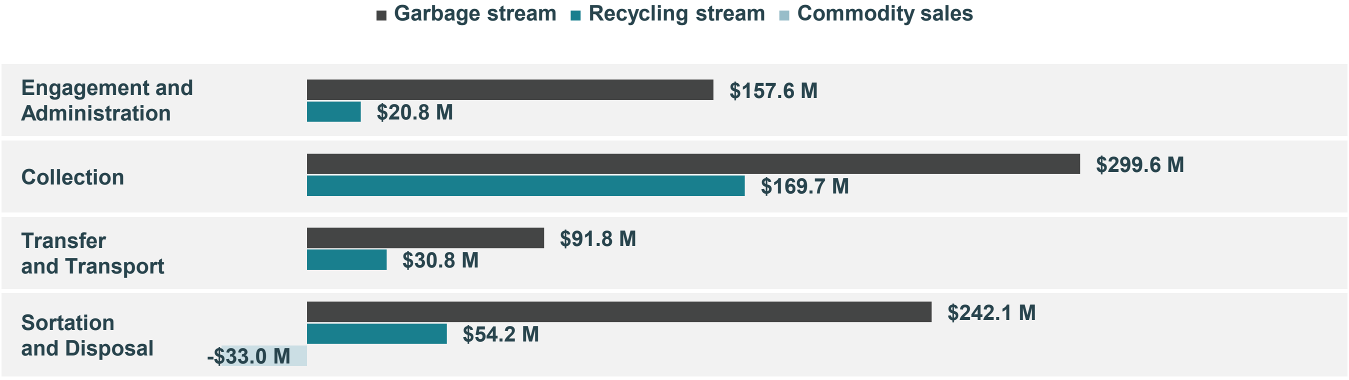
Propane canisters

SCENARIO AT-A-GLANCE

Scenario 10 uses the USCL from S03. A lower number of PRO depots than S09 collect shredded paper, aerosol cans, aluminum foil, expanded polystyrene foam, plastic film, and additional plastic items. Glass continues to be collected at curbside in Metro and is collected at PRO depots elsewhere in the state.

Tons Collected for Recycling	541.8k
Tons Properly Recycled	495.2k
Inbound Contamination Rate	10.63%
Outbound Bale Contamination Rate	1.97%
Statewide Direct Cost	$1,033.6 M
Statewide Indirect Cost	-$515.9 M
Statewide Net Cost	$517.8 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$306
Net Cost Per Ton Generated	$153

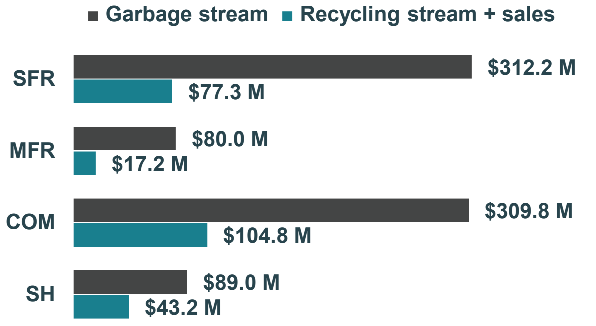
TOTAL DIRECT COST (by stream and phase)



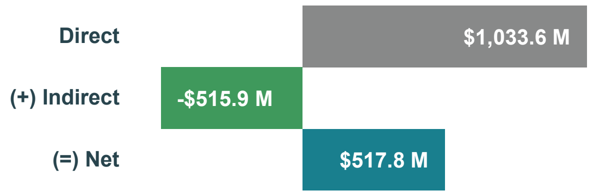
Total market/direct cost of garbage: $791.1 M

Total market/direct cost of recycling (net commodity sales): $242.5 M

TOTAL DIRECT COST
(by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul

k = thousands
M = millions

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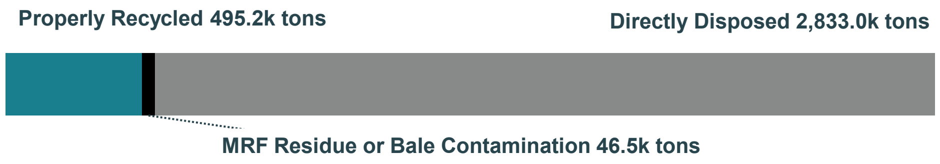
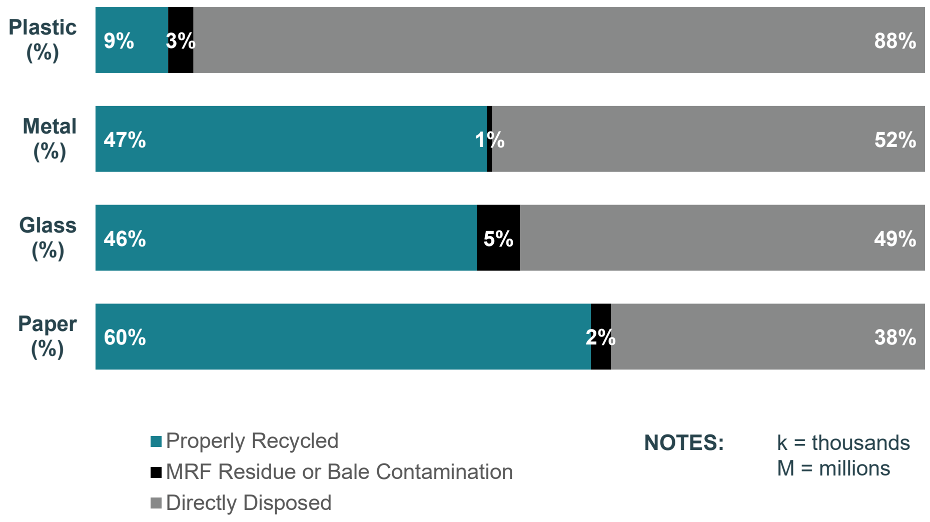
Scenario 10 Profile

S10

DISPOSITION OF ALL MATERIALS
(tonnage, overall)

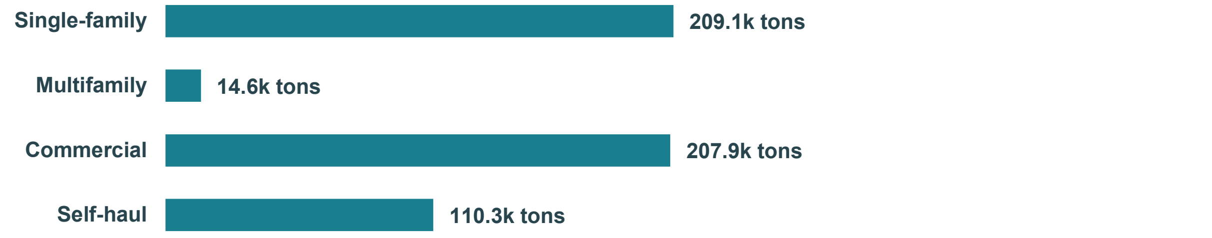


DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

541.8 thousand tons collected for recycling



447.2 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 41.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 11 Profile

S11

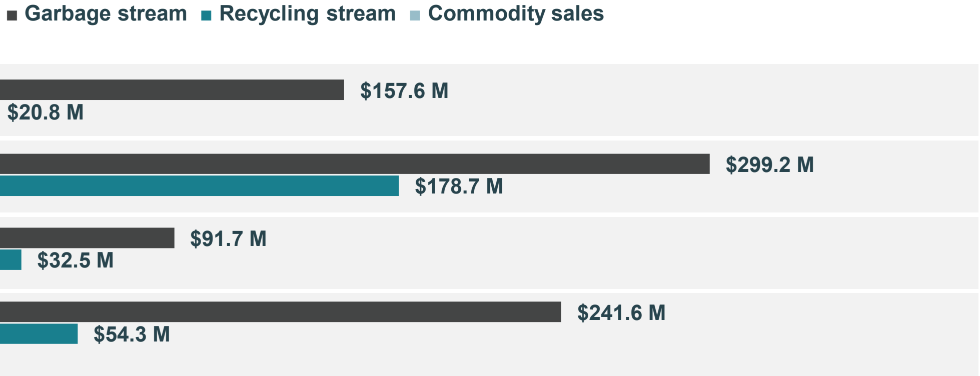
Material	
CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

SCENARIO AT-A-GLANCE

Scenario 11 uses the USCL from S03. A higher number of PRO depots than S09 collect shredded paper, aerosol cans, aluminum foil, expanded polystyrene foam, plastic film, and additional plastic items. Glass continues to be collected at curbside in Metro and is collected at PRO depots elsewhere in the state.

Tons Collected for Recycling	546.7k
Tons Properly Recycled	500.0k
Inbound Contamination Rate	10.60%
Outbound Bale Contamination Rate	1.99%
Statewide Direct Cost	$1,043.3 M
Statewide Indirect Cost	-$519.8 M
Statewide Net Cost	$523.5 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$309
Net Cost Per Ton Generated	$155

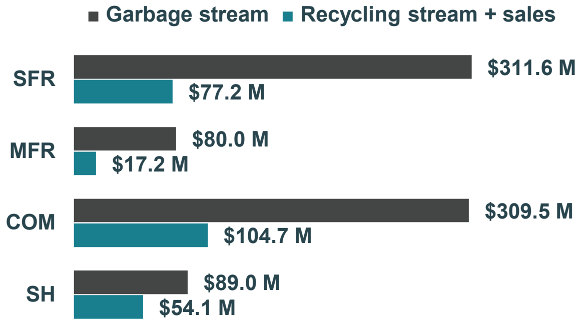
TOTAL DIRECT COST (by stream and phase)



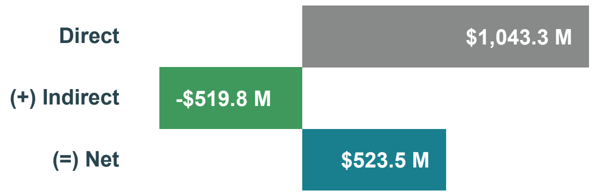
Total market/direct cost of garbage: $790.1 M

Total market/direct cost of recycling (net commodity sales): $253.2 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul
k = thousands
M = millions

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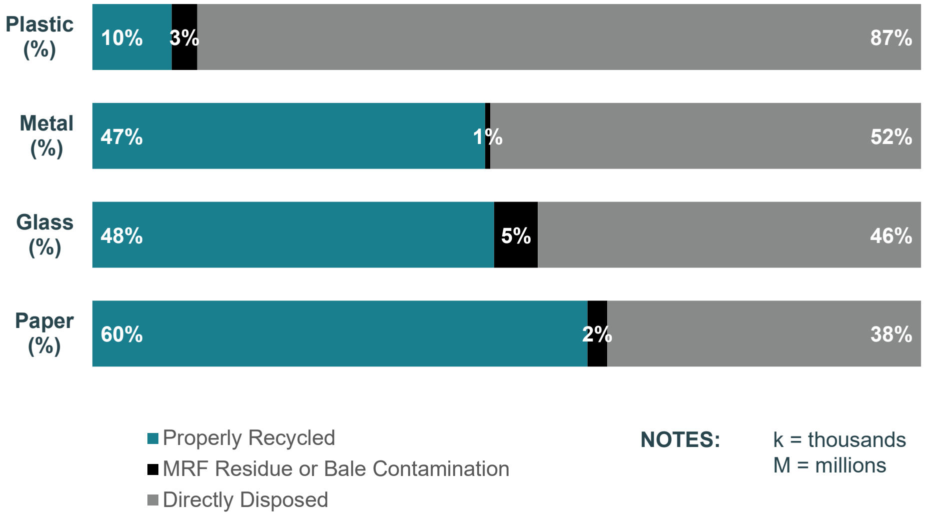
Scenario 11 Profile

S11

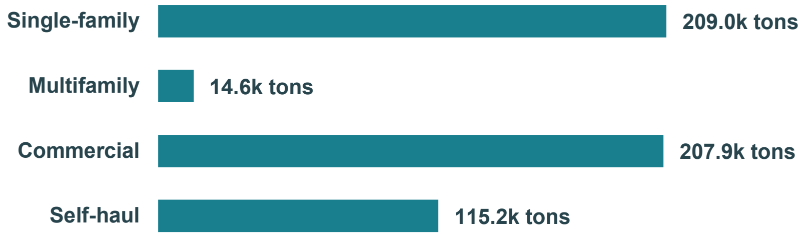
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

546.7 thousand tons collected for recycling



452.0 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 41.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 12 Profile

S12

- CORE USCL
- Glass
- PET, HDPE, PP tubs
- PET clamshells (thermoforms)
- Polycoated cartons & cups
- HDPE, PP, PET pails & cups
- Rigid PS, other food serviceware
- Aerosols
- Bulky HDPE, PP products
- Lids & film
- Aluminum foil & foil products
- Shredded paper
- Block EPS
- Propane canisters

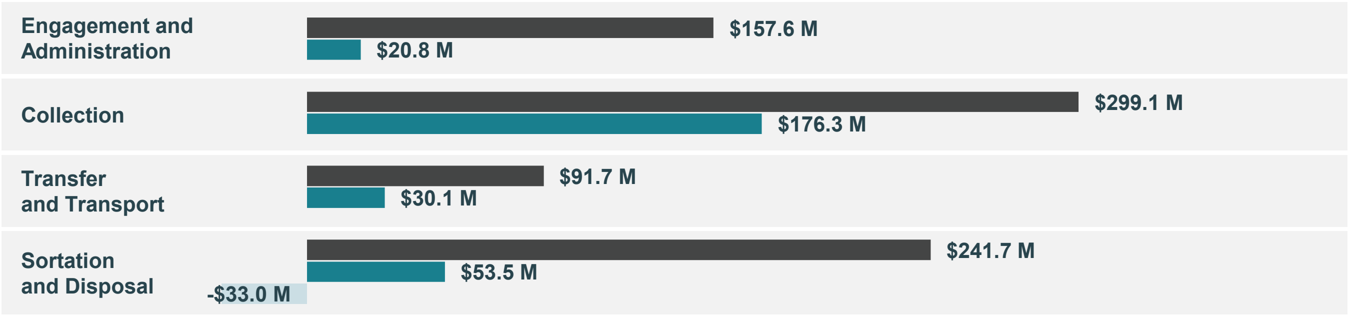
SCENARIO AT-A-GLANCE

Scenario 12 uses the S01 USCL, accepting only core USCL materials. Glass is collected at curbside. A medium number of PRO depots collect shredded paper, aerosol cans, aluminum foil, expanded polystyrene foam, plastic film, and certain rigid plastics. PRO depots also collect tubs, clamshells, cups, and cartons that were in the S03 USCL.

Tons Collected for Recycling	547.0k
Tons Properly Recycled	502.0k
Inbound Contamination Rate	10.75%
Outbound Bale Contamination Rate	1.97%
Statewide Direct Cost	$1,037.7 M
Statewide Indirect Cost	-$517.1 M
Statewide Net Cost	$520.6 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$307
Net Cost Per Ton Generated	$154

TOTAL DIRECT COST (by stream and phase)

■ Garbage stream ■ Recycling stream ■ Commodity sales

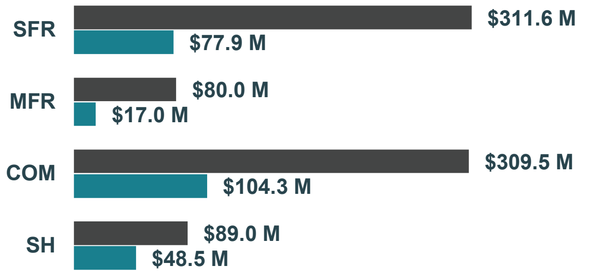


Total market/direct cost of garbage: $790.0 M

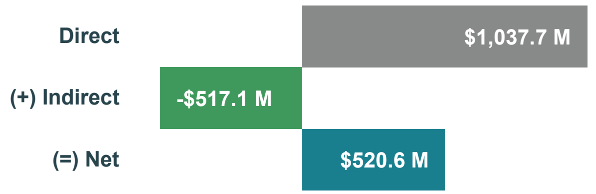
Total market/direct cost of recycling (net commodity sales): $247.7 M

TOTAL DIRECT COST (by stream and sector)

■ Garbage stream ■ Recycling stream + sales



TOTAL COST



NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul

k = thousands
M = millions

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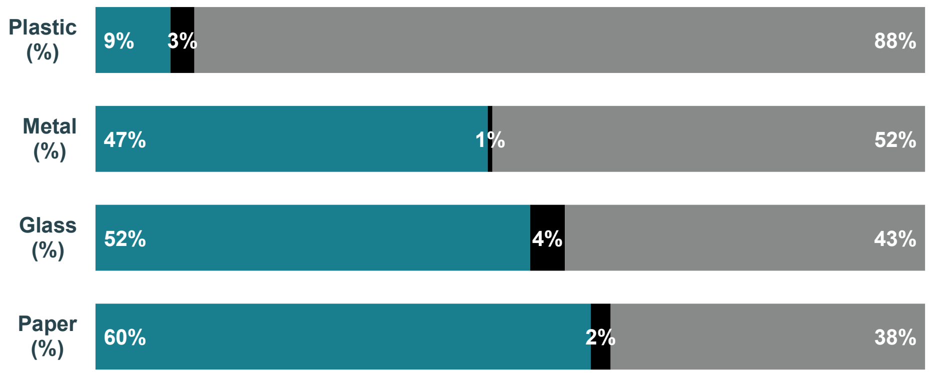
Scenario 12 Profile

S12

DISPOSITION OF ALL MATERIALS
(tonnage, overall)

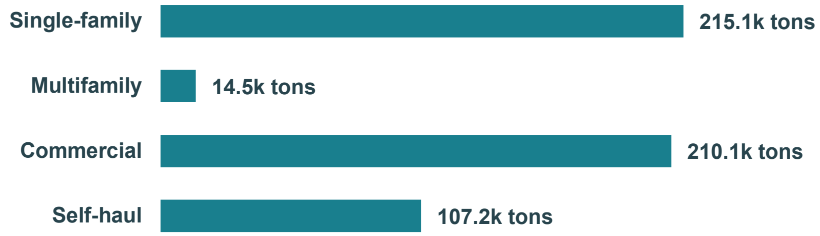
DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



■ Properly Recycled
■ MRF Residue or Bale Contamination
■ Directly Disposed

NOTES: k = thousands
M = millions

547.0 thousand tons collected for recycling



454.0 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 39.7 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 13 Profile

S13

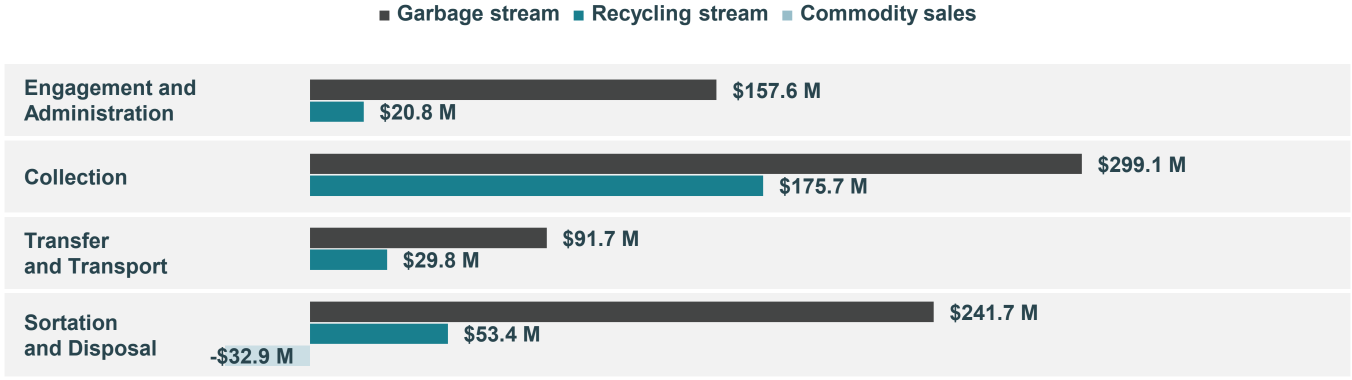
Material	
CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

SCENARIO AT-A-GLANCE

Scenario 13 uses the S01 USCL, accepting only core USCL materials. Glass is collected at curbside. A medium number of PRO depots collect shredded paper, aerosol cans, aluminum foil, plastic film, and certain rigid plastics. PRO depots collect tubs, clamshells, cups, and cartons that were in the S03 USCL. Expanded polystyrene foam is not collected.

Tons Collected for Recycling	546.7k
Tons Properly Recycled	501.7k
Inbound Contamination Rate	10.75%
Outbound Bale Contamination Rate	1.97%
Statewide Direct Cost	$1,036.9 M
Statewide Indirect Cost	-$516.5 M
Statewide Net Cost	$520.4 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$307
Net Cost Per Ton Generated	$154

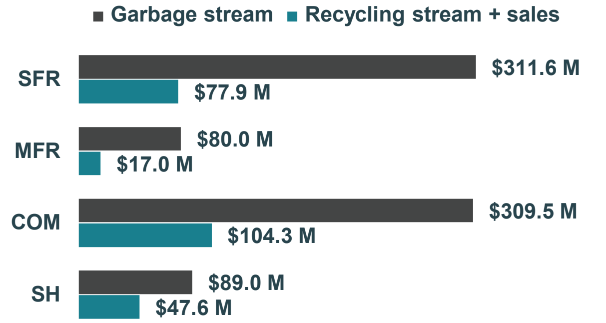
TOTAL DIRECT COST (by stream and phase)



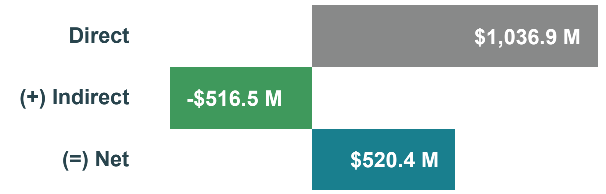
Total market/direct cost of garbage: $790.1 M

Total market/direct cost of recycling (net commodity sales): $246.8 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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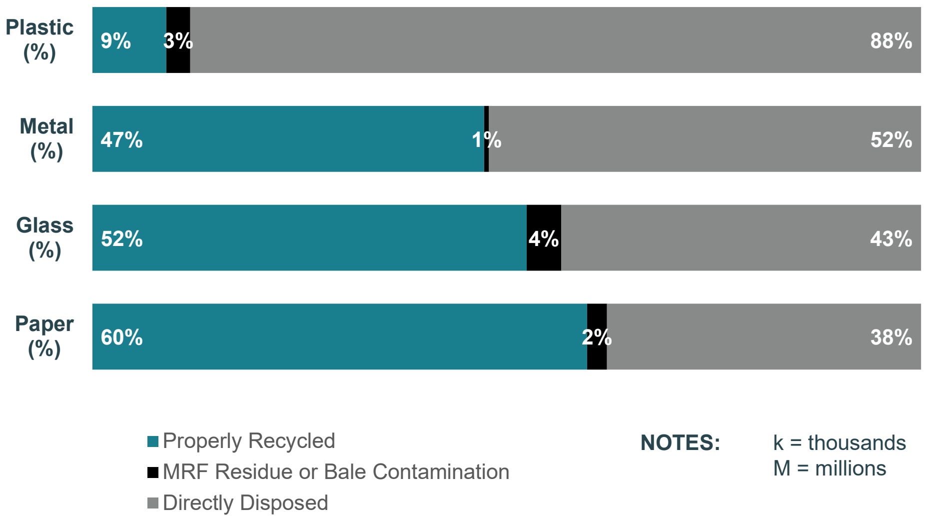
S13

Scenario 13 Profile

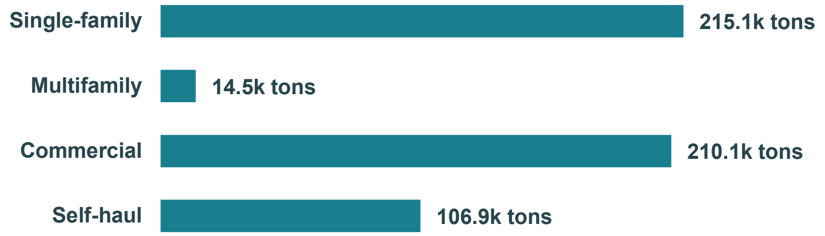
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

546.7 thousand tons collected for recycling



453.7 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 39.7 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

Scenario 14 Profile

S14

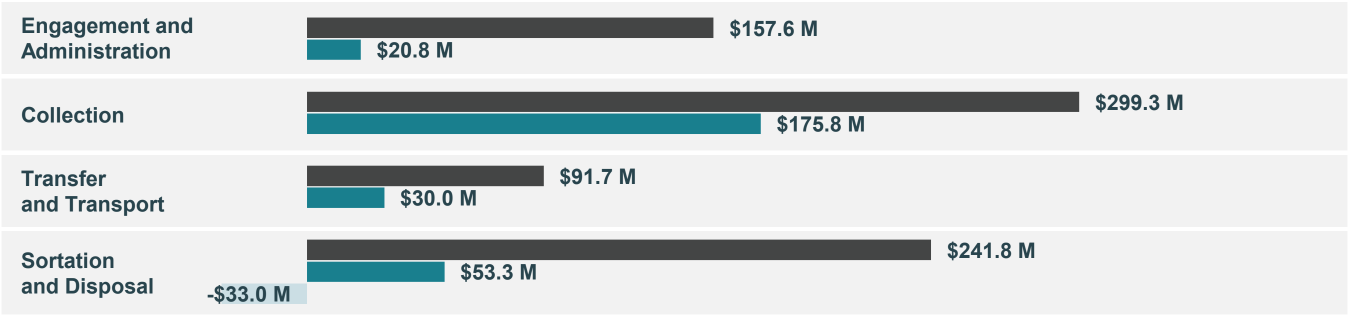
- CORE USCL
- Glass
- PET, HDPE, PP tubs
- PET clamshells (thermoforms)
- Polycoated cartons & cups
- HDPE, PP, PET pails & cups
- Rigid PS, other food serviceware
- Aerosols
- Bulky HDPE, PP products
- Lids & film
- Aluminum foil & foil products
- Shredded paper
- Block EPS
- Propane canisters

SCENARIO AT-A-GLANCE

Scenario 14 uses the S01 USCL, accepting only core USCL materials. Glass is collected at curbside. A medium number of PRO depots collect shredded paper, aerosol cans, aluminum foil, expanded polystyrene foam, plastic film, and certain rigid plastics. PRO depots collect tubs, clamshells, and plastic cups that were in the S03 USCL. Polycoated cartons and cups are not collected.

Tons Collected for Recycling	545.4k
Tons Properly Recycled	500.6k
Inbound Contamination Rate	10.68%
Outbound Bale Contamination Rate	1.97%
Statewide Direct Cost	$1,037.3 M
Statewide Indirect Cost	-$514.4 M
Statewide Net Cost	$522.9 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$307
Net Cost Per Ton Generated	$155

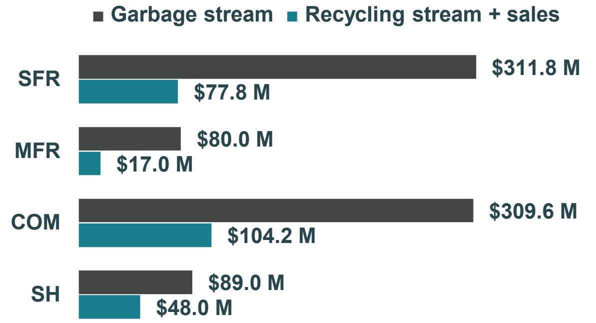
TOTAL DIRECT COST (by stream and phase)



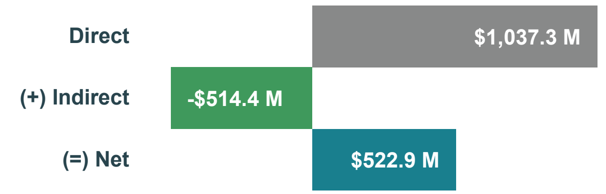
Total market/direct cost of garbage: $790.4 M

Total market/direct cost of recycling (net commodity sales): $246.9 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul

k = thousands
M = millions

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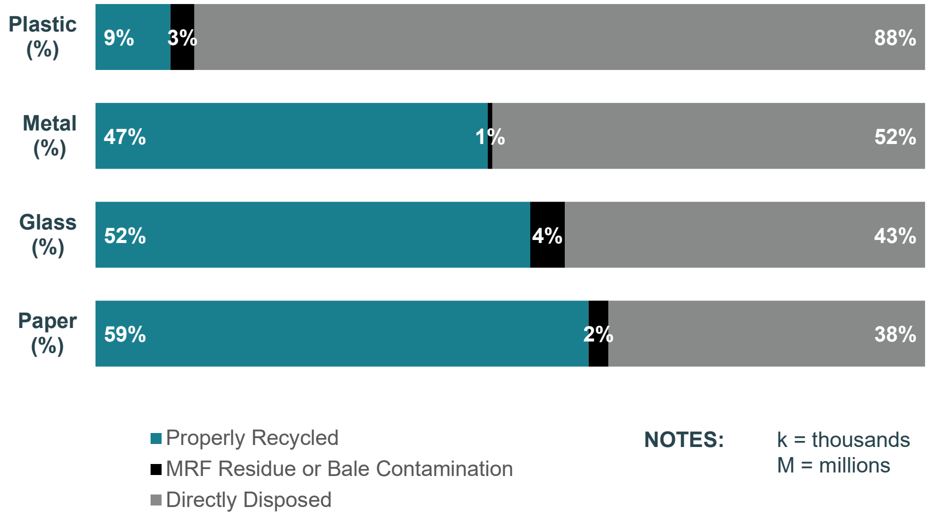
Scenario 14 Profile

S14

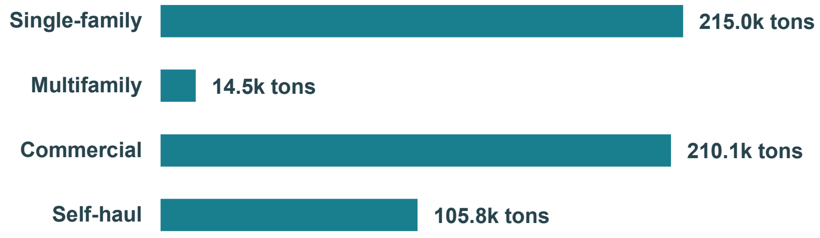
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

545.4 thousand tons collected for recycling



452.5 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 39.5 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 15 Profile

S15

- CORE USCL
- Glass
- PET, HDPE, PP tubs
- PET clamshells (thermoforms)
- Polycoated cartons & cups
- HDPE, PP, PET pails & cups
- Rigid PS, other food serviceware
- Aerosols
- Bulky HDPE, PP products
- Lids & film
- Aluminum foil & foil products
- Shredded paper
- Block EPS
- Propane canisters

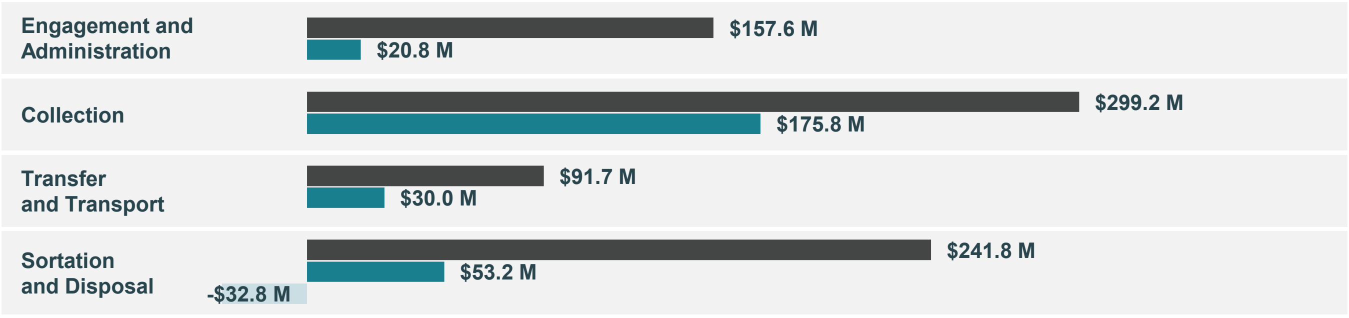
SCENARIO AT-A-GLANCE

Scenario 15 uses the S01 USCL, accepting only core USCL materials. Glass is collected at curbside. A medium number of PRO depots collect shredded paper, aluminum foil, expanded polystyrene foam, and plastic film. PRO depots also collect tubs, clamshells, cups, and cartons that were in the S03 USCL. Aerosol cans and certain plastics (certain pails, rigid polystyrene, and other food serviceware) are not collected.

Tons Collected for Recycling	545.6k
Tons Properly Recycled	500.7k
Inbound Contamination Rate	10.84%
Outbound Bale Contamination Rate	1.96%
Statewide Direct Cost	$1,037.3 M
Statewide Indirect Cost	-$515.9 M
Statewide Net Cost	$521.4 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$307
Net Cost Per Ton Generated	$154

TOTAL DIRECT COST (by stream and phase)

■ Garbage stream ■ Recycling stream ■ Commodity sales

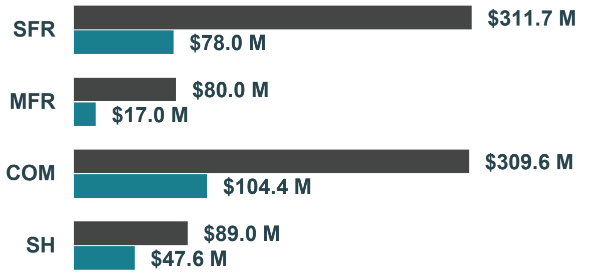


Total market/direct cost of garbage: $790.3 M

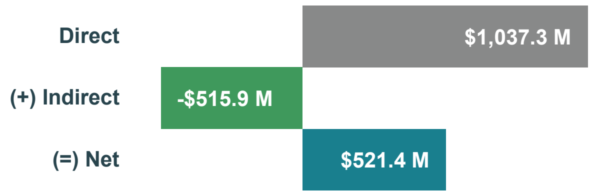
Total market/direct cost of recycling (net commodity sales): $247.0 M

TOTAL DIRECT COST (by stream and sector)

■ Garbage stream ■ Recycling stream + sales



TOTAL COST



NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul
k = thousands
M = millions

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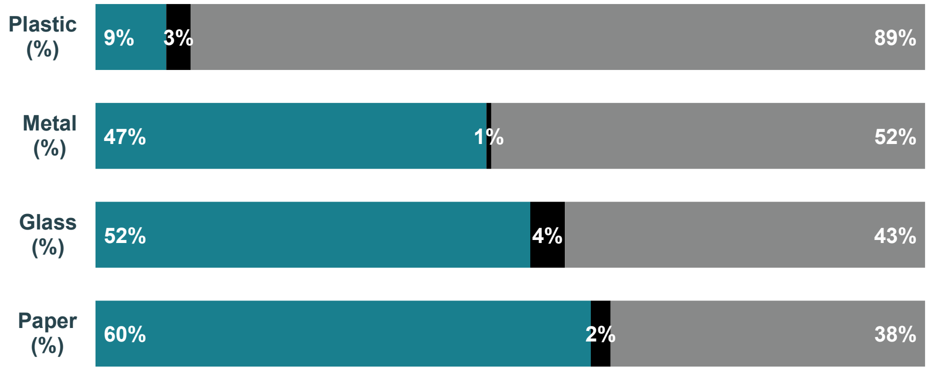
Scenario 15 Profile

S15

DISPOSITION OF ALL MATERIALS
(tonnage, overall)

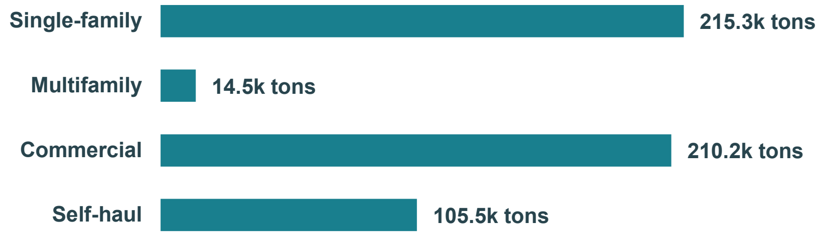
DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



Properly Recycled
MRF Residue or Bale Contamination
Directly Disposed

NOTES: k = thousands
M = millions

545.6 thousand tons collected for recycling



452.6 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.2 thousand tons were outbound bale contamination
- 39.8 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 16 Profile

S16

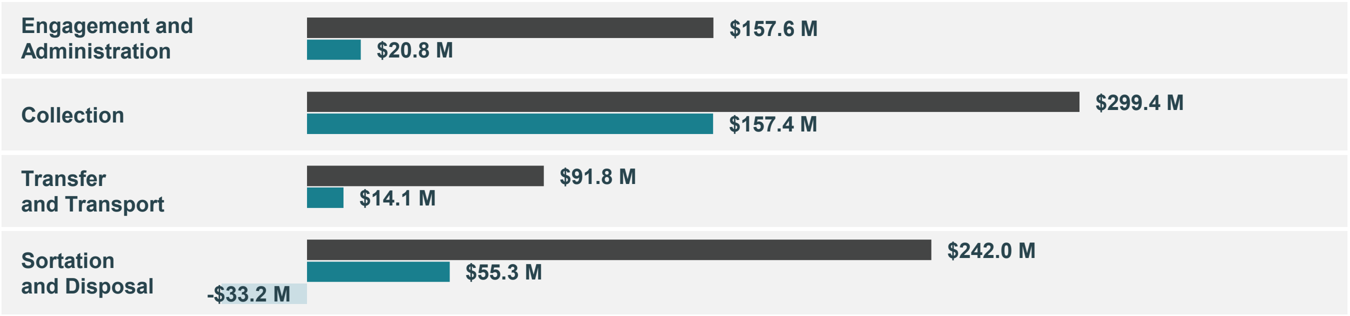
CORE USCL	Recycling
Glass	Recycling (curbside)
PET, HDPE, PP tubs	Recycling
PET clamshells (thermoforms)	Recycling
Polycoated cartons & cups	Recycling
HDPE, PP, PET pails & cups	Recycling
Rigid PS, other food serviceware	Recycling
Aerosols	Recycling
Bulky HDPE, PP products	Recycling
Lids & film	Not collected
Aluminum foil & foil products	Not collected
Shredded paper	Not collected
Block EPS	Not collected
Propane canisters	Not collected

SCENARIO AT-A-GLANCE

Scenario 16 builds on the S03 USCL list by adding certain plastics (certain pails, rigid polystyrene, other food serviceware), bulky HDPE and PP products, and aerosol cans. Glass is collected at curbside and there are no PRO depots.

Tons Collected for Recycling	544.1k
Tons Properly Recycled	496.2k
Inbound Contamination Rate	9.77%
Outbound Bale Contamination Rate	2.00%
Statewide Direct Cost	$1,005.2 M
Statewide Indirect Cost	-$506.2 M
Statewide Net Cost	$499.1 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$298
Net Cost Per Ton Generated	$148

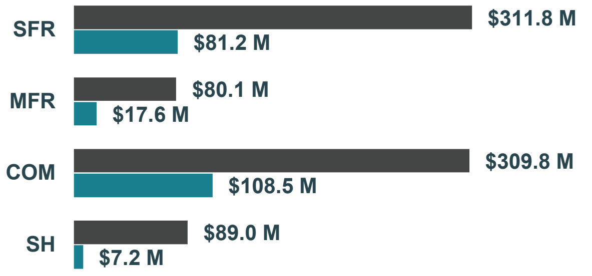
TOTAL DIRECT COST (by stream and phase)



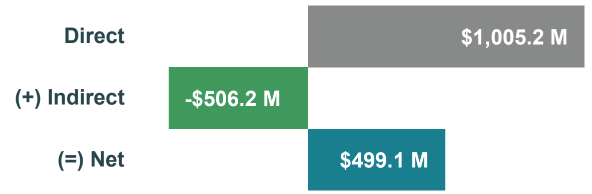
Total market/direct cost of garbage: $790.7 M

Total market/direct cost of recycling (net commodity sales): $214.5 M

TOTAL DIRECT COST
(by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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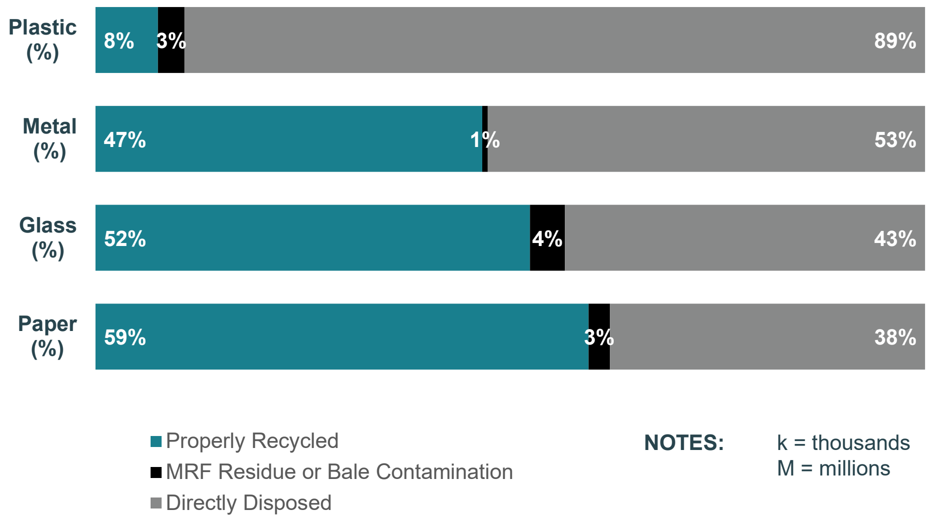
Scenario 16 Profile

S16

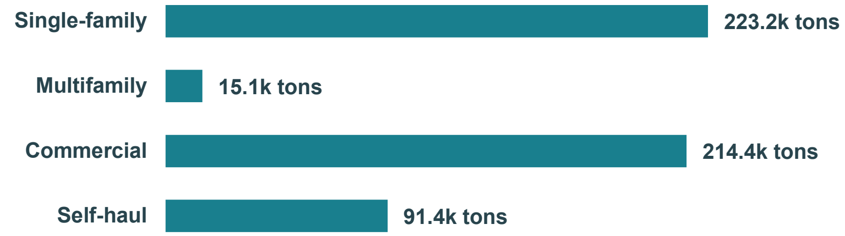
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

544.1 thousand tons collected for recycling



448.2 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.4 thousand tons were outbound bale contamination
- 42.5 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 17 Profile

S17

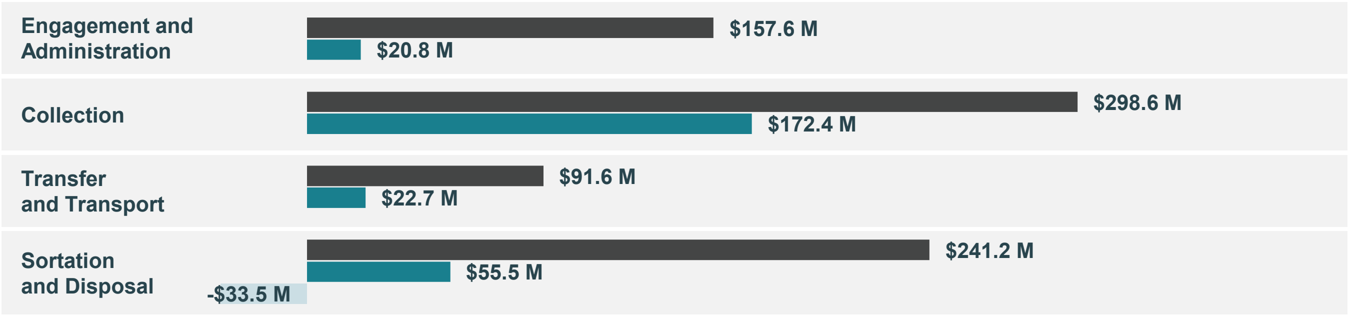
CORE USCL
Glass
PET, HDPE, PP tubs
PET clamshells (thermoforms)
Polycoated cartons & cups
HDPE, PP, PET pails & cups
Rigid PS, other food serviceware
Aerosols
Bulky HDPE, PP products
Lids & film
Aluminum foil & foil products
Shredded paper
Block EPS
Propane canisters

SCENARIO AT-A-GLANCE

Scenario 17 uses the S16 USCL (a longer list than S03). Glass is collected at curbside. A medium number of PRO depots collect shredded paper, aluminum foil, expanded polystyrene foam, plastic film, and plastic lids.

Tons Collected for Recycling	551.7k
Tons Properly Recycled	503.2k
Inbound Contamination Rate	9.93%
Outbound Bale Contamination Rate	2.01%
Statewide Direct Cost	$1,026.9 M
Statewide Indirect Cost	-$518.5 M
Statewide Net Cost	$508.5 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$304
Net Cost Per Ton Generated	$151

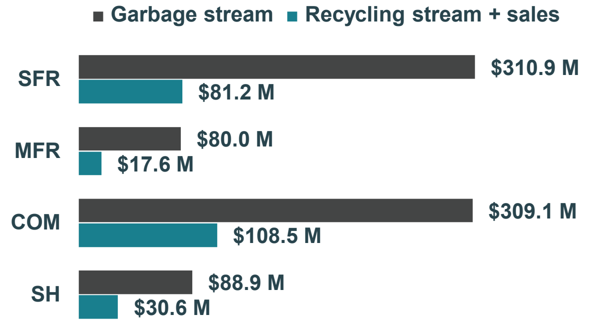
TOTAL DIRECT COST (by stream and phase)



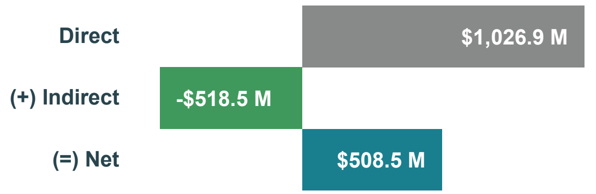
Total market/direct cost of garbage: $789.0 M

Total market/direct cost of recycling (net commodity sales): $238.0 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST

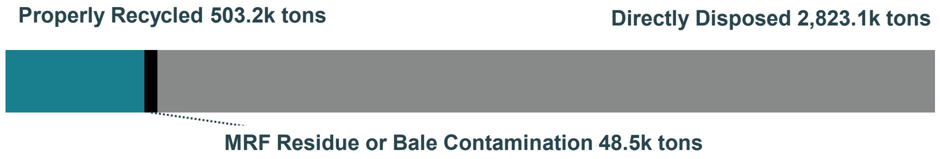


NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul
k = thousands
M = millions

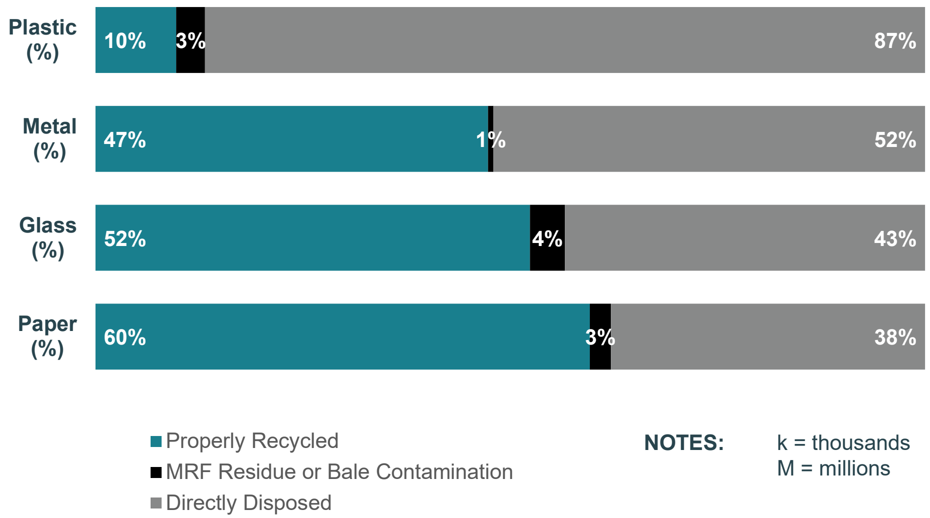
Scenario 17 Profile

S17

DISPOSITION OF ALL MATERIALS
(tonnage, overall)

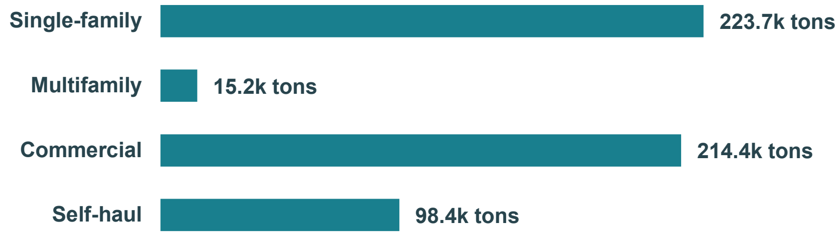


DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

551.7 thousand tons collected for recycling



455.1 thousand tons properly recycled by material category

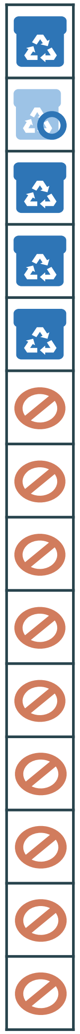
What happened to the rest of the material?

- 5.4 thousand tons were outbound bale contamination
- 43.1 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

Scenario 18 Profile

S18

CORE USCL
Glass
PET, HDPE, PP tubs
PET clamshells (thermoforms)
Polycoated cartons & cups
HDPE, PP, PET pails & cups
Rigid PS, other food serviceware
Aerosols
Bulky HDPE, PP products
Lids & film
Aluminum foil & foil products
Shredded paper
Block EPS
Propane canisters

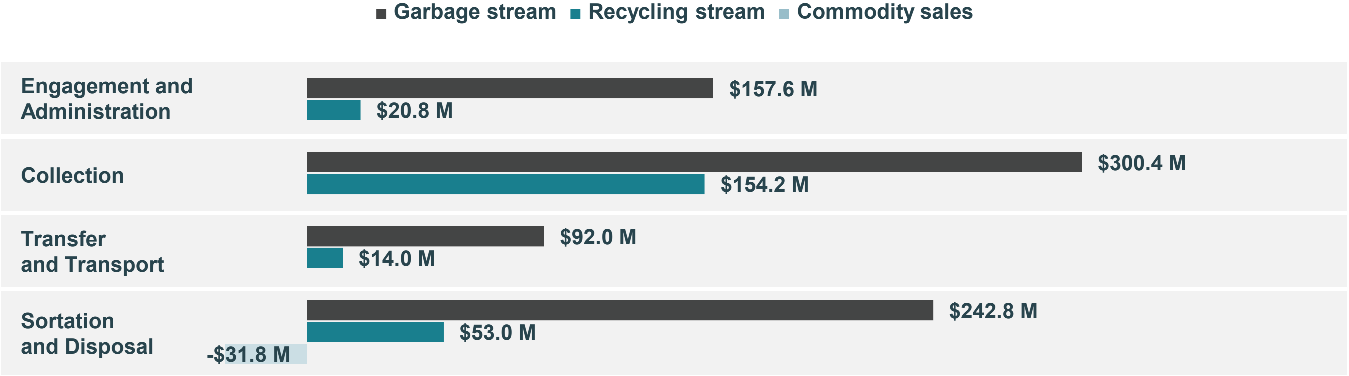


SCENARIO AT-A-GLANCE

Scenario 18 uses the USCL from S03. Glass continues to be collected at curbside everywhere in the state, but instead of using a mix of collection vehicles, all haulers use only dedicated glass-only trucks, representing an extreme case for glass collection. There are no PRO depots.

Tons Collected for Recycling	535.1k
Tons Properly Recycled	490.7k
Inbound Contamination Rate	9.96%
Outbound Bale Contamination Rate	1.95%
Statewide Direct Cost	$1,003.0 M
Statewide Indirect Cost	-$500.8 M
Statewide Net Cost	$502.1 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$297
Net Cost Per Ton Generated	$149

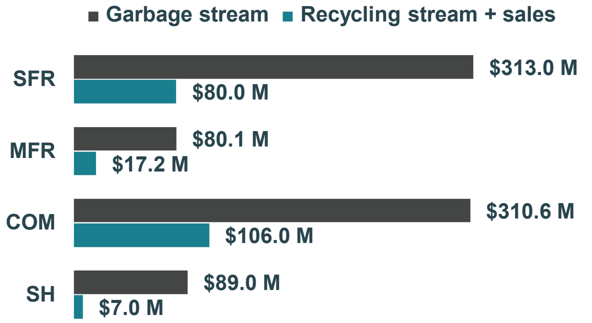
TOTAL DIRECT COST (by stream and phase)



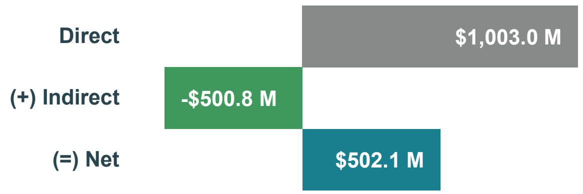
Total market/direct cost of garbage: $792.7 M

Total market/direct cost of recycling (net commodity sales): $210.2 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul

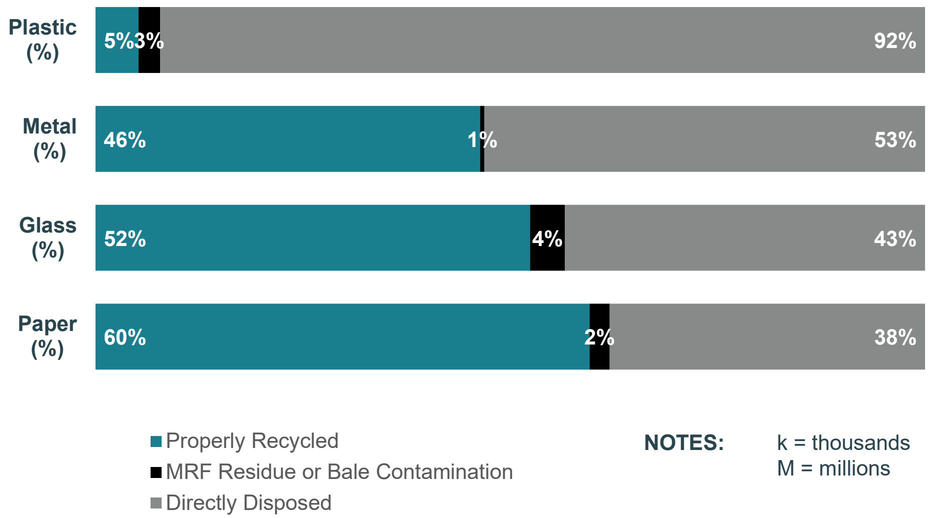
k = thousands
M = millions

Scenario 18 Profile

S18

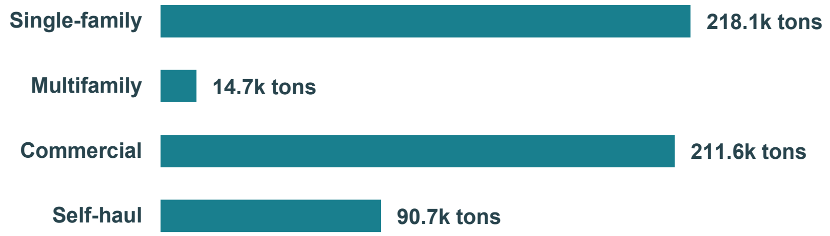
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

535.1 thousand tons collected for recycling



442.7 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.1 thousand tons were outbound bale contamination
- 39.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 19 Profile

S19

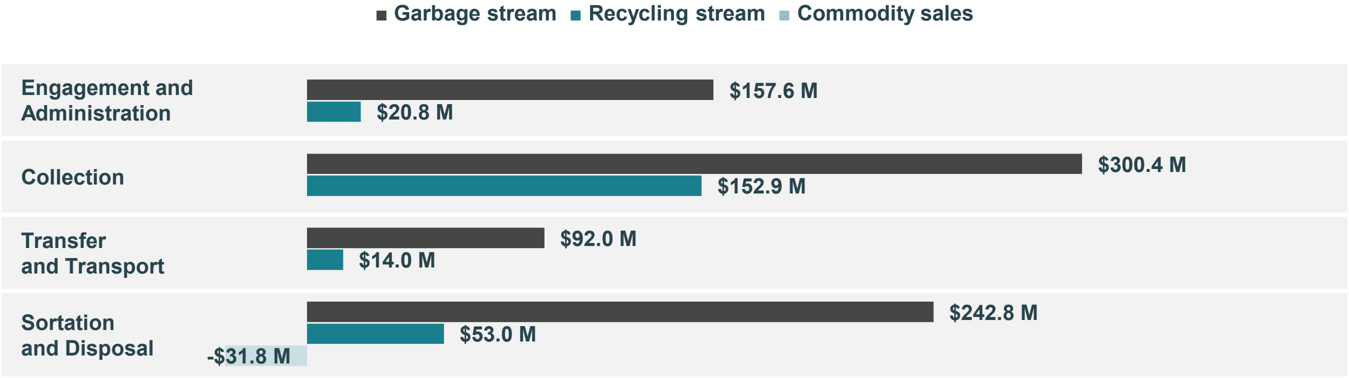
- CORE USCL
- Glass
- PET, HDPE, PP tubs
- PET clamshells (thermoforms)
- Polycoated cartons & cups
- HDPE, PP, PET pails & cups
- Rigid PS, other food serviceware
- Aerosols
- Bulky HDPE, PP products
- Lids & film
- Aluminum foil & foil products
- Shredded paper
- Block EPS
- Propane canisters

SCENARIO AT-A-GLANCE

Scenario 19 uses the USCL from S03. Glass continues to be collected at curbside everywhere in the state, but instead of using a mix of collection vehicles, all haulers collect glass only in dual-compartment trucks that pick up both commingled recycling and glass – the opposite extreme of S18. There are no PRO depots.

Tons Collected for Recycling	535.1k
Tons Properly Recycled	490.7k
Inbound Contamination Rate	9.96%
Outbound Bale Contamination Rate	1.95%
Statewide Direct Cost	$1,001.7 M
Statewide Indirect Cost	-$504.5 M
Statewide Net Cost	$497.2 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$297
Net Cost Per Ton Generated	$147

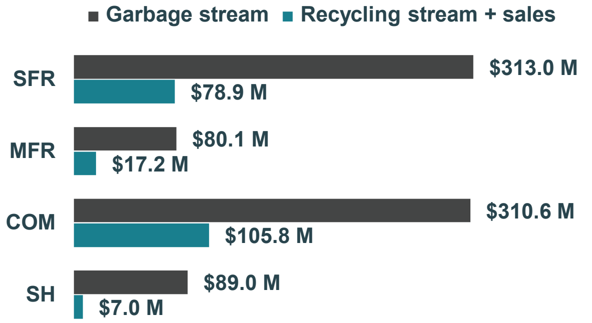
TOTAL DIRECT COST (by stream and phase)



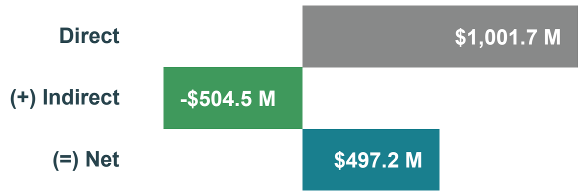
Total market/direct cost of garbage: $792.7 M

Total market/direct cost of recycling (net commodity sales): $209.0 M

TOTAL DIRECT COST
(by stream and sector)



TOTAL COST



NOTES:
SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul
k = thousands
M = millions

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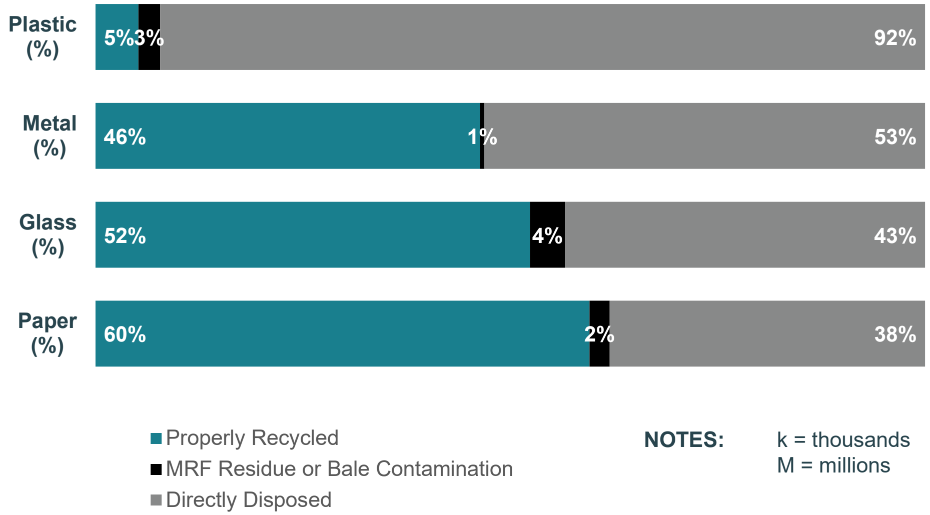
Scenario 19 Profile

S19

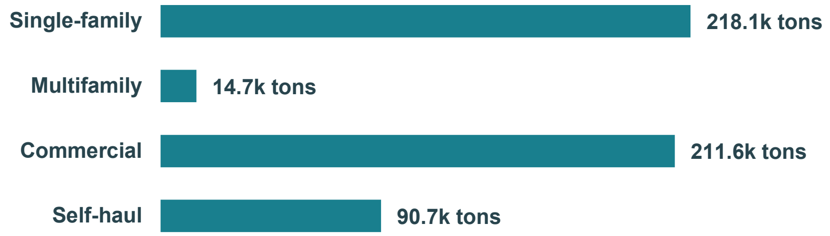
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

535.1 thousand tons collected for recycling



442.7 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.1 thousand tons were outbound bale contamination
- 39.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 20 Profile

S20

CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

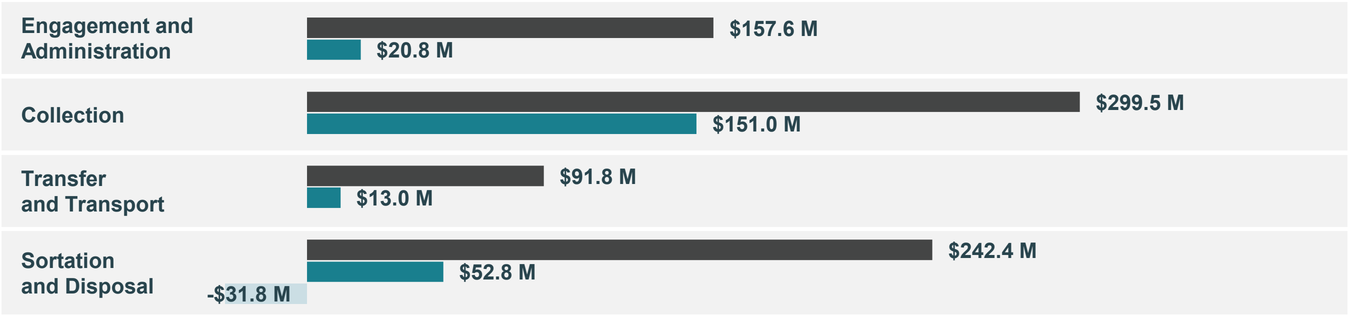
SCENARIO AT-A-GLANCE

Scenario 20 uses the USCL from S03. Glass continues to be collected at curbside everywhere in the state using a mix of collection vehicles, but the Bottle Bill has been expanded to include wine and liquor bottles, reducing the glass available for curbside collection. The extra glass recycled through the Bottle Bill is reflected in recycling rates but not collection costs. There are no PRO depots.

Tons Collected for Recycling	502.0k
Tons Properly Recycled	497.4k
Inbound Contamination Rate	9.65%
Outbound Bale Contamination Rate	1.95%
Statewide Direct Cost	$997.1 M
Statewide Indirect Cost	-$508.0 M
Statewide Net Cost	$489.1 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$295
Net Cost Per Ton Generated	$145

TOTAL DIRECT COST (by stream and phase)

■ Garbage stream ■ Recycling stream ■ Commodity sales

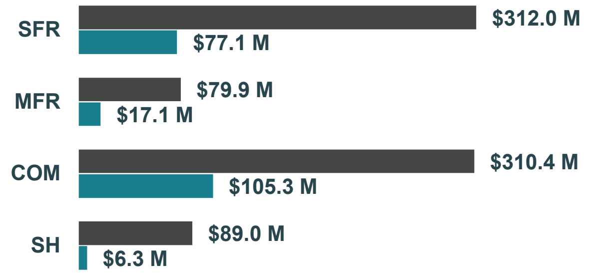


Total market/direct cost of garbage: $791.3 M

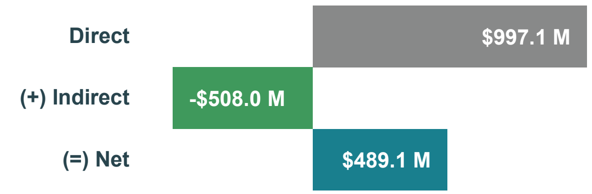
Total market/direct cost of recycling (net commodity sales): $205.8 M

TOTAL DIRECT COST (by stream and sector)

■ Garbage stream ■ Recycling stream + sales



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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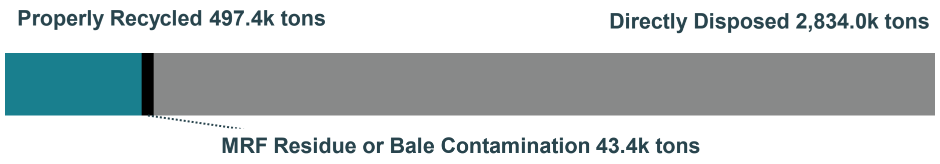
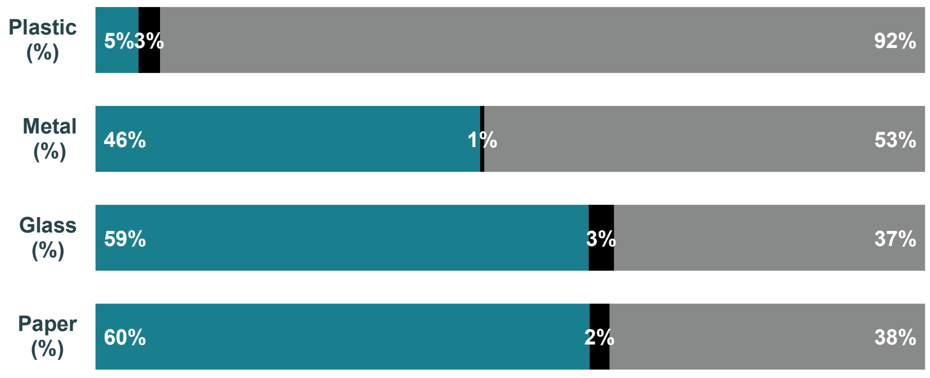
Scenario 20 Profile

S20

DISPOSITION OF ALL MATERIALS
(tonnage, overall)



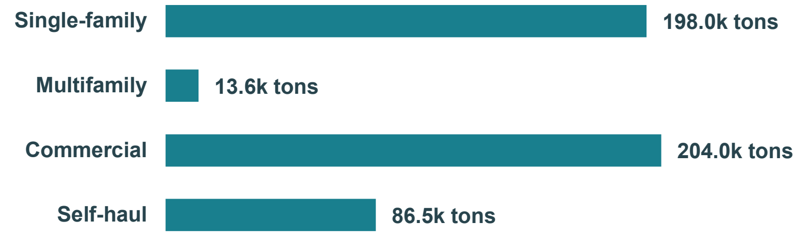
DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



■ Properly Recycled
■ MRF Residue or Bale Contamination
■ Directly Disposed

NOTES: k = thousands
M = millions

502.0 thousand tons collected for recycling



449.3 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.1 thousand tons were outbound bale contamination
- 38.3 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 21 Profile

S21

CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

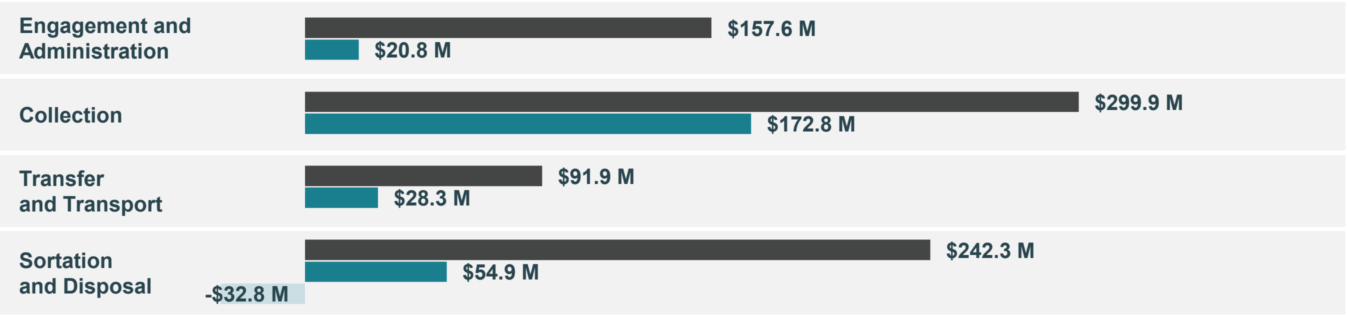
SCENARIO AT-A-GLANCE

Scenario 21 slightly varies from the S03 USCL list by excluding PET clamshells but adding HDPE, PP, and PET pails and cups. A medium number of PRO depots collect shredded paper, aluminum foil, expanded polystyrene foam, aerosol cans, and propane canisters. A high number of PRO depots collect plastic film, lids, and glass. MRFs have an extra unders recovery system to capture undersized material that would otherwise be lost to residuals.

Tons Collected for Recycling	540.6k
Tons Properly Recycled	492.9k
Inbound Contamination Rate	10.93%
Outbound Bale Contamination Rate	1.98%
Statewide Direct Cost	$1,035.7 M
Statewide Indirect Cost	-$524.1 M
Statewide Net Cost	$511.6 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$307
Net Cost Per Ton Generated	$152

TOTAL DIRECT COST (by stream and phase)

■ Garbage stream ■ Recycling stream ■ Commodity sales

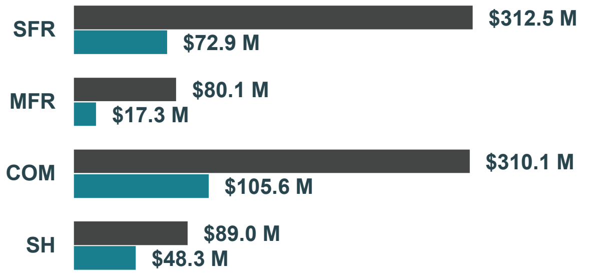


Total market/direct cost of garbage: $791.6 M

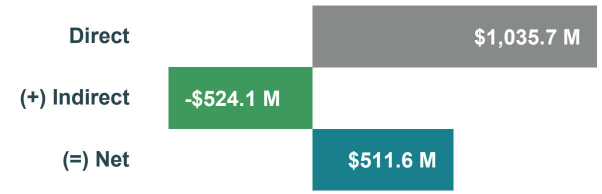
Total market/direct cost of recycling (net commodity sales): $244.1 M

TOTAL DIRECT COST
(by stream and sector)

■ Garbage stream ■ Recycling stream + sales



TOTAL COST



NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul

k = thousands
M = millions

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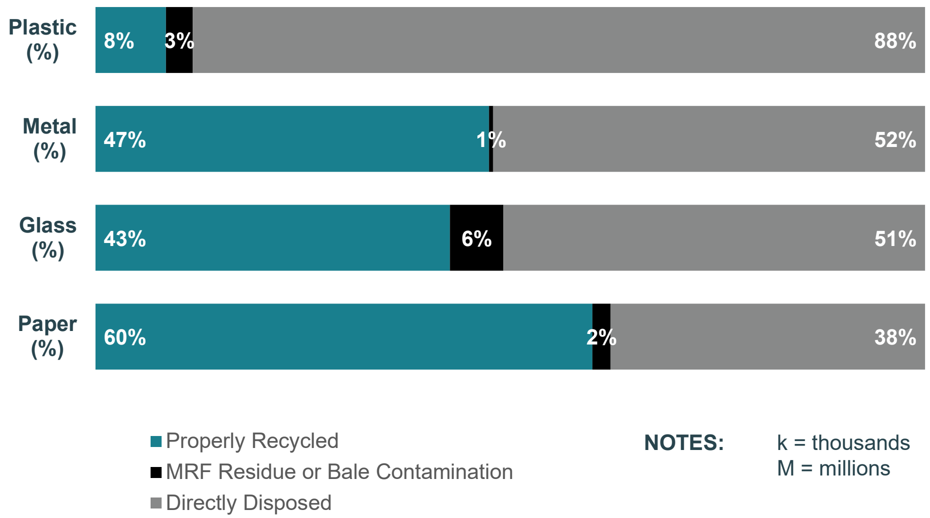
Scenario 21 Profile

S21

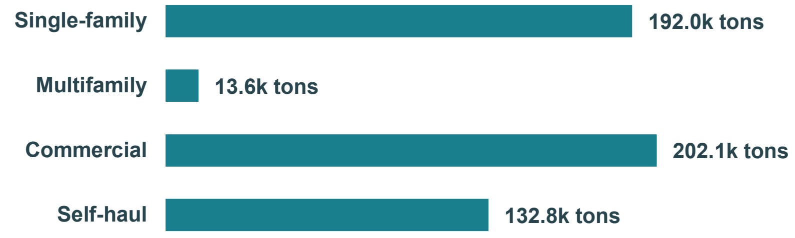
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

540.6 thousand tons collected for recycling



444.8 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 42.4 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 22 Profile

S22

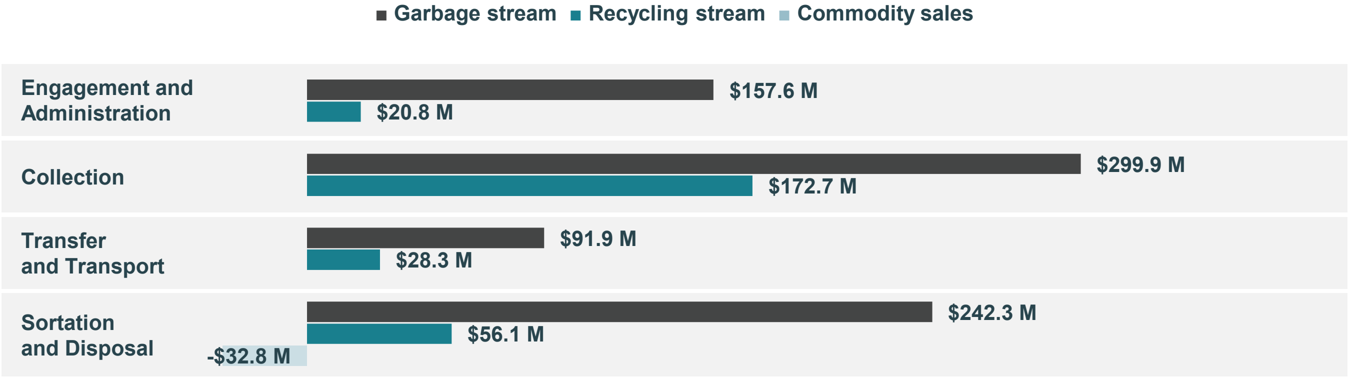
CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

SCENARIO AT-A-GLANCE

Scenario 22 slightly varies from the S21 USCL list by adding aerosol cans. A medium number of PRO depots collect shredded paper, aluminum foil, expanded polystyrene foam, and propane canisters. A high number of PRO depots collect plastic film, lids, and glass. MRFs have an extra unders recovery system.

Tons Collected for Recycling	540.6k
Tons Properly Recycled	492.9k
Inbound Contamination Rate	10.92%
Outbound Bale Contamination Rate	1.98%
Statewide Direct Cost	$1,036.7 M
Statewide Indirect Cost	-$524.2 M
Statewide Net Cost	$512.5 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$307
Net Cost Per Ton Generated	$152

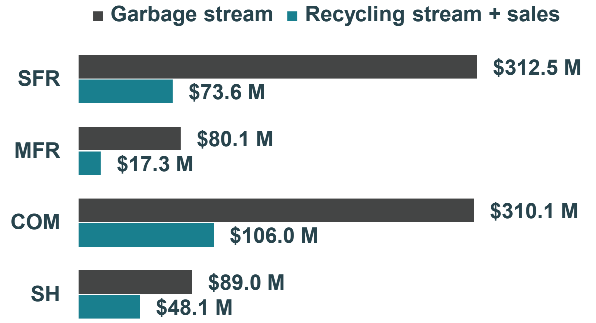
TOTAL DIRECT COST (by stream and phase)



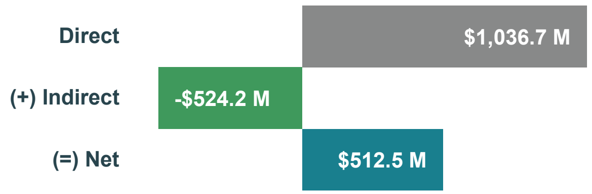
Total market/direct cost of garbage: $791.6 M

Total market/direct cost of recycling (net commodity sales): $245.1 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential
MFR = multifamily residential
COM = commercial
SH = self-haul

k = thousands
M = millions

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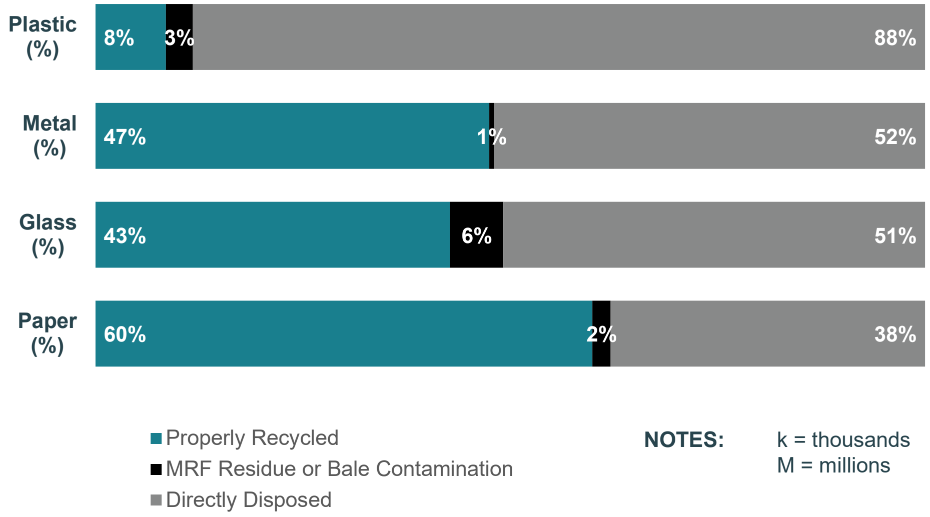
Scenario 22 Profile

S22

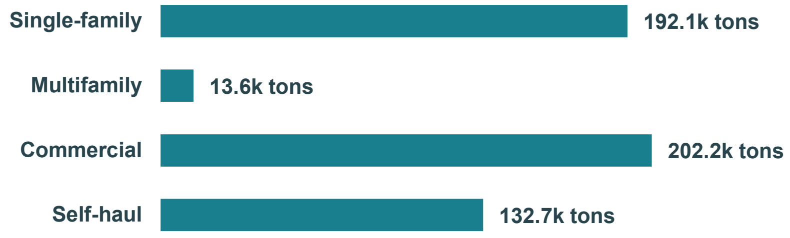
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

540.6 thousand tons collected for recycling



444.9 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 42.4 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

Scenario 23 Profile

S23

- **CORE USCL**
- **Glass**
- **PET, HDPE, PP tubs**
- **PET clamshells (thermoforms)**
- **Polycoated cartons & cups**
- **HDPE, PP, PET pails & cups**
- **Rigid PS, other food serviceware**
- **Aerosols**
- **Bulky HDPE, PP products**
- **Lids & film**
- **Aluminum foil & foil products**
- **Shredded paper**
- **Block EPS**
- **Propane canisters**

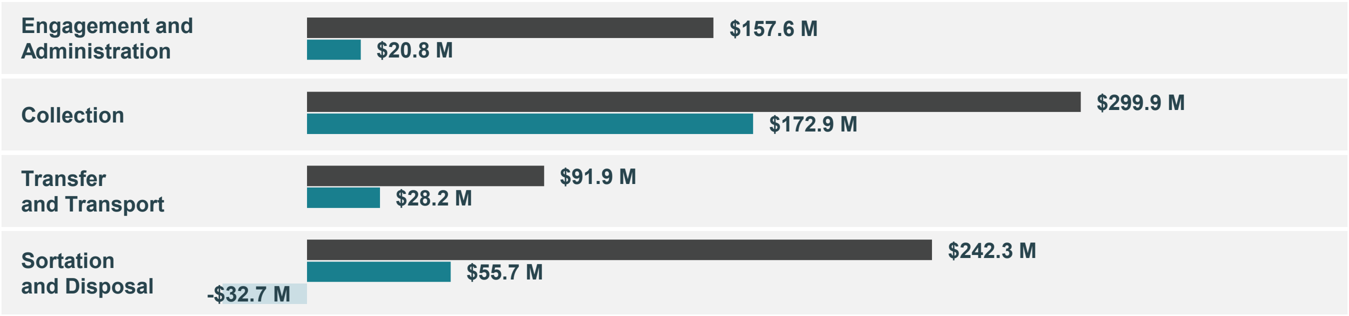
SCENARIO AT-A-GLANCE

Scenario 23 slightly varies from the S21 USCL list by adding aluminum foil. A medium number of PRO depots collect shredded paper, aerosol cans, expanded polystyrene foam, and propane canisters. A high number of PRO depots collect plastic film, lids, and glass. MRFs have an extra unders recovery system and also create a foil-only bale.

Tons Collected for Recycling	540.7k
Tons Properly Recycled	492.9k
Inbound Contamination Rate	10.88%
Outbound Bale Contamination Rate	1.98%
Statewide Direct Cost	$1,036.5 M
Statewide Indirect Cost	-$524.4 M
Statewide Net Cost	$512.1 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$307
Net Cost Per Ton Generated	$152

TOTAL DIRECT COST (by stream and phase)

Garbage stream ■ Recycling stream ■ Commodity sales

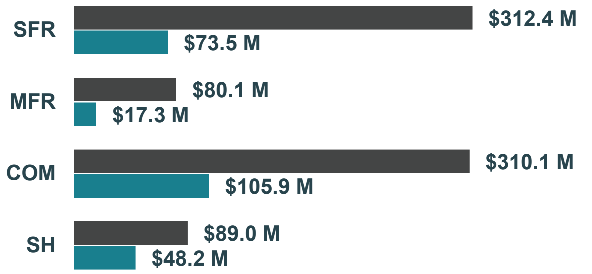


Total market/direct cost of garbage: $791.6 M

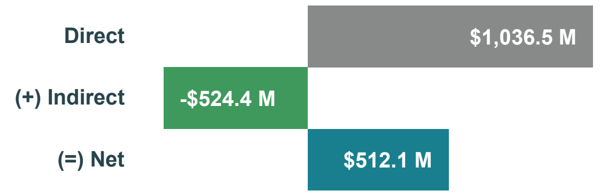
Total market/direct cost of recycling (net commodity sales): $244.9 M

TOTAL DIRECT COST (by stream and sector)

Garbage stream ■ Recycling stream + sales



TOTAL COST



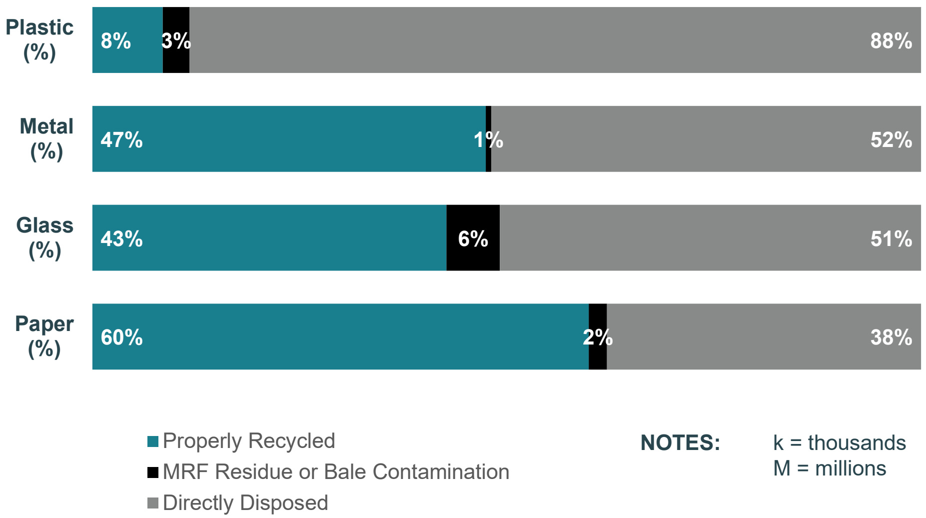
NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

Scenario 23 Profile

S23

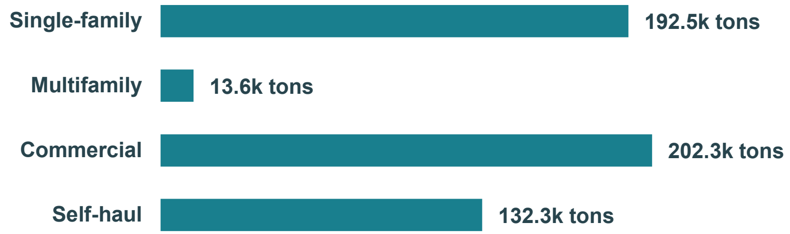
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

540.7 thousand tons collected for recycling



444.9 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 42.5 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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Scenario 24 Profile

S24

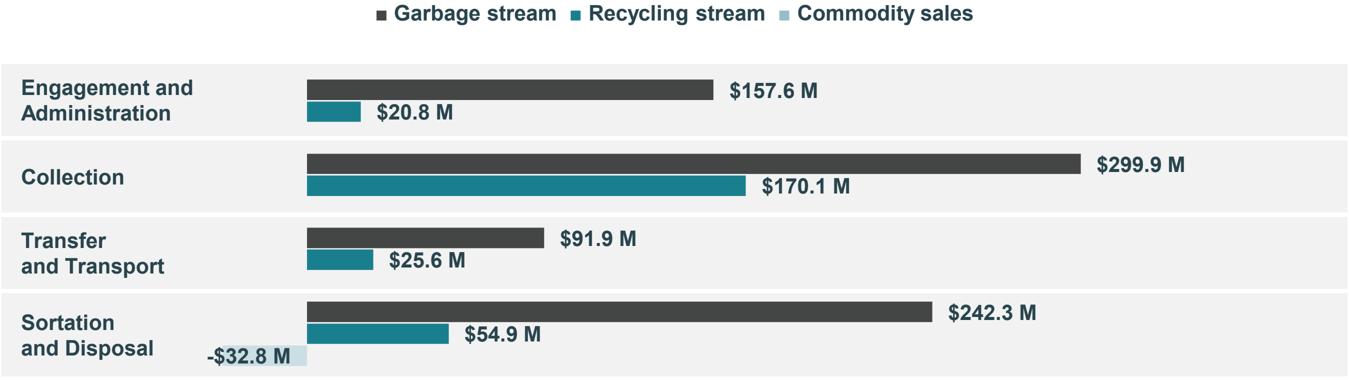
CORE USCL	
Glass	
PET, HDPE, PP tubs	
PET clamshells (thermoforms)	
Polycoated cartons & cups	
HDPE, PP, PET pails & cups	
Rigid PS, other food serviceware	
Aerosols	
Bulky HDPE, PP products	
Lids & film	
Aluminum foil & foil products	
Shredded paper	
Block EPS	
Propane canisters	

SCENARIO AT-A-GLANCE

Scenario 24 exactly matches the S21 but assumes a different mix of PRO depot types. S21 and S24 use the same number of co-collection depots at existing solid waste sites. S24 uses fewer multi-material depots that collect the full range of PRO depot materials. Instead, S24 adds many more return-to-retail and single-material depots.

Tons Collected for Recycling	540.6k
Tons Properly Recycled	492.9k
Inbound Contamination Rate	10.93%
Outbound Bale Contamination Rate	1.98%
Statewide Direct Cost	$1,030.3 M
Statewide Indirect Cost	-$525.0 M
Statewide Net Cost	$505.3 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$305
Net Cost Per Ton Generated	$150

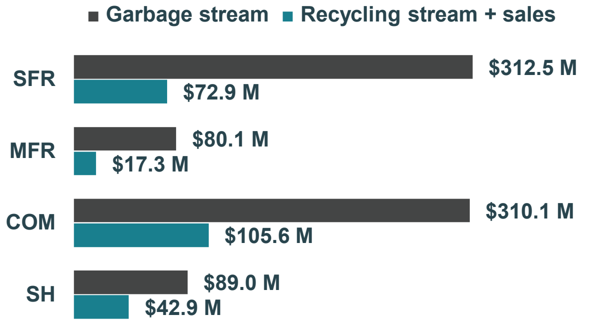
TOTAL DIRECT COST (by stream and phase)



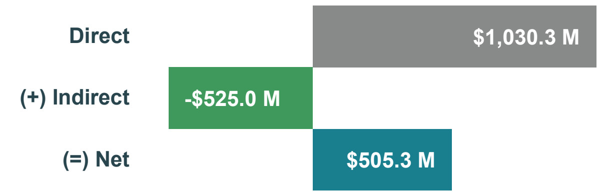
Total market/direct cost of garbage: $791.6 M

Total market/direct cost of recycling (net commodity sales): $238.7 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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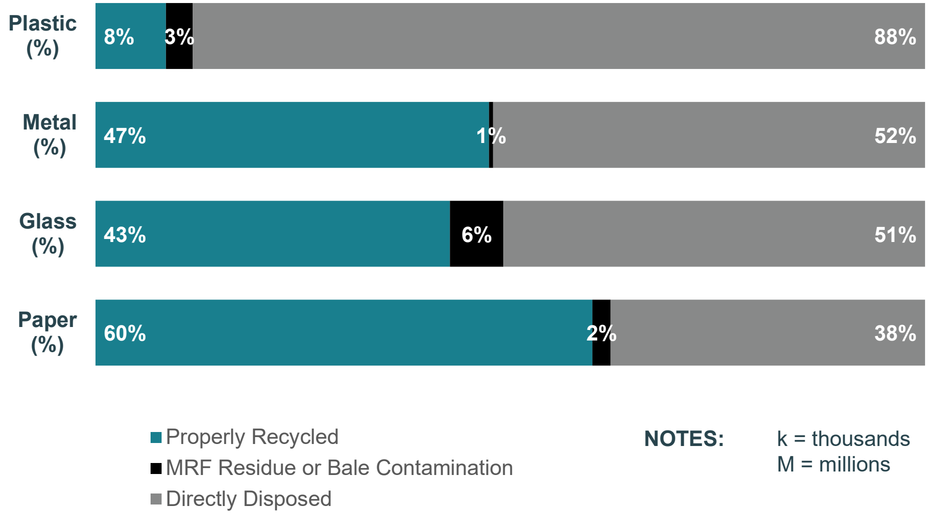
Scenario 24 Profile

S24

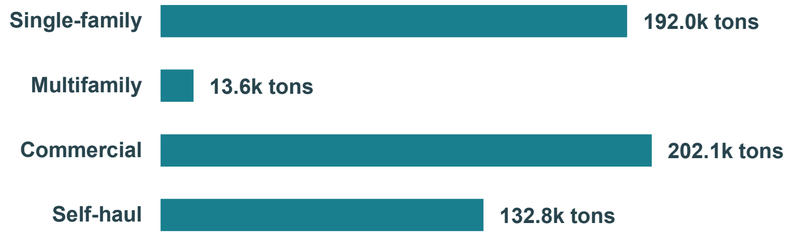
DISPOSITION OF ALL MATERIALS
(tonnage, overall)

DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)



NOTES: k = thousands
M = millions

540.6 thousand tons collected for recycling



444.8 thousand tons properly recycled by material category

What happened to the rest of the material?

- 5.3 thousand tons were outbound bale contamination
- 42.4 thousand tons disposed as MRF residue
- 48.1 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

Scenario 25 Profile

S25

Note: chart axes on this slide are different from axes on other scenario profile slides

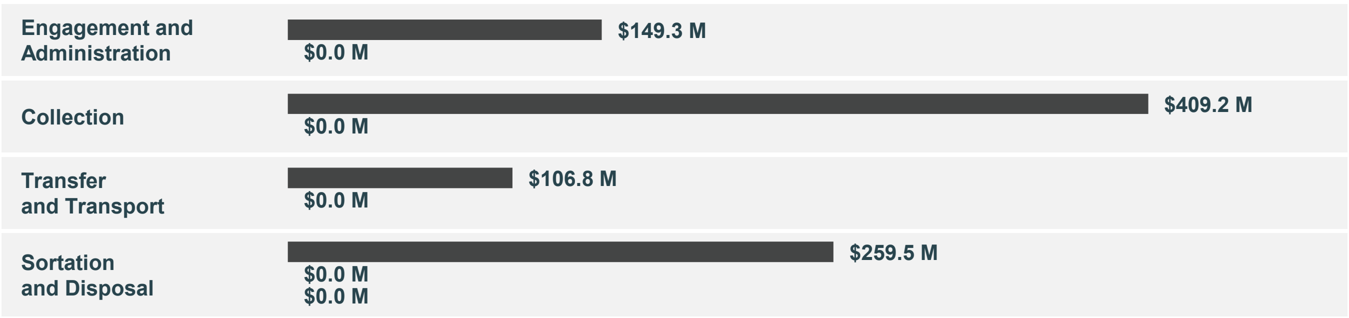
- CORE USCL
- Glass
- PET, HDPE, PP tubs
- PET clamshells (thermoforms)
- Polycoated cartons & cups
- HDPE, PP, PET pails & cups
- Rigid PS, other food serviceware
- Aerosols
- Bulky HDPE, PP products
- Lids & film
- Aluminum foil & foil products
- Shredded paper
- Block EPS
- Propane canisters

SCENARIO AT-A-GLANCE

Scenario 25 assumes there is no recycling by franchised, licensed, or permitted solid waste collectors or solid waste disposal sites. All in-scope materials that were recycled in S00 (the baseline) are collected and disposed of as garbage. Changes in direct costs reflect the elimination of recycling collection, processing of recyclables, and recycling programs that are currently funded by disposal tip fees.

Tons Collected for Recycling	.0k
Tons Properly Recycled	.0k
Inbound Contamination Rate	NA
Outbound Bale Contamination Rate	0.00%
Statewide Direct Cost	$924.9 M
Statewide Indirect Cost	$619.8 M
Statewide Net Cost	$1,544.7 M
Tons Generated (excl. organics)	3,374.8k
Direct Cost Per Ton Generated	$274
Net Cost Per Ton Generated	$458

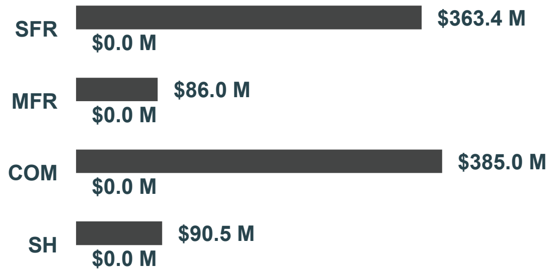
TOTAL DIRECT COST (by stream and phase)



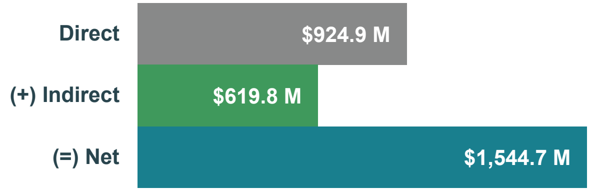
Total market/direct cost of garbage: $924.9 M

Total market/direct cost of recycling (net commodity sales): $0.0 M

TOTAL DIRECT COST (by stream and sector)



TOTAL COST



NOTES: SFR = single-family residential; MFR = multifamily residential; COM = commercial; SH = self-haul; k = thousands; M = millions

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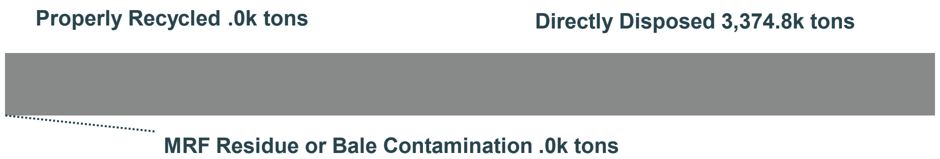
Scenario 25 Profile

S25

DISPOSITION OF ALL MATERIALS
(tonnage, overall)



DISPOSITION OF POTENTIALLY RECOVERABLE MATERIALS
(percentage, by material type)

- Properly Recycled
- MRF Residue or Bale Contamination
- Directly Disposed

NOTES: k = thousands
M = millions

0.0 thousand tons collected for recycling

Single-family	.0k tons
Multifamily	.0k tons
Commercial	.0k tons
Self-haul	.0k tons

0.0 thousand tons properly recycled by material category

Paper	.0k tons
Glass	.0k tons
Metal	.0k tons
Plastic	.0k tons

What happened to the rest of the material?

- 0.0 thousand tons were outbound bale contamination
- 0.0 thousand tons disposed as MRF residue
- 0.0 thousand tons were recycled materials that do not vary between scenarios (e.g., motor oil)

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APPENDIX B. Tonnage and direct cost model methodology

By Jessica Branom-Zwick
jessica@cascadiaconsulting.com

March 14, 2023

Introduction

This appendix describes the methodology and data sources for the tonnage and direct cost modeling that were developed by an external consulting team for DEQ.

It starts with an overview of the model, including describing the five modules, model outputs and limitations, the scope of materials and geographic areas, data sources, and the scenarios analyzed.

The rest of this appendix describes how materials are handled through the solid waste system and the modules:

1. **Establishing baseline tons** of materials generated and recycled
2. **Forecasting future commingled (USCL) tons** collected.
3. **Estimating collection costs** for on-route and solid waste depot collection.
4. **Forecasting future PRO depot tons** collected through estimating new capture rates
5. **Estimating collection costs** for PRO depot collection.
6. **Modeling material transport** destinations, distances, and costs
7. **Modeling sortation** results and costs at MRFs

EXTERNAL CONSULTANT TEAM

Cascadia Consulting Group, Inc.

Jessica Branom-Zwick, Senior Associate, led Cascadia's work on this project, developing the model and working with stakeholders to refine the analyses. Jessica has over 16 years of experience in evaluating, modeling, and analyzing waste and recycling programs using Cascadia's waste characterization data supplemented by external studies, evaluations, PRO annual reports, and other research. Cascadia has managed more than 500 waste characterization studies for more than 100 distinct clients from statewide to MRF-level to document material flows and program performance. Jessica was supported by Analysts Carolina Paez Jimenez, Angela Pietschmann, and Kirstin Hervin.

Bell & Associates, Inc.

Chris Bell is a Certified Public Accountant, licensed in Oregon, practicing in integrated solid waste management with an emphasis on the financial analysis and operational evaluation of waste and recycling collection systems. He has 22 years of experience assisting public and private entities with setting collection rates, financial and performance audits, and facility and systems analysis. In 2022, he reviewed the financial results of 22 franchised collection companies, audited four companies, and set rates for nine jurisdictions in Oregon.

Circular Matters, LLC

Tim Buwalda, Principal at Circular Matters, has over 25 years of comprehensive recycling and solid waste management consulting experience, working extensively with companies and trade associations throughout North America. He has a diverse range of hands-on experience and knowledge in materials recovery facility design, financial analysis, policy analysis, recycling program evaluation and optimization, and development of recycling solutions for plastics and recovered paper.

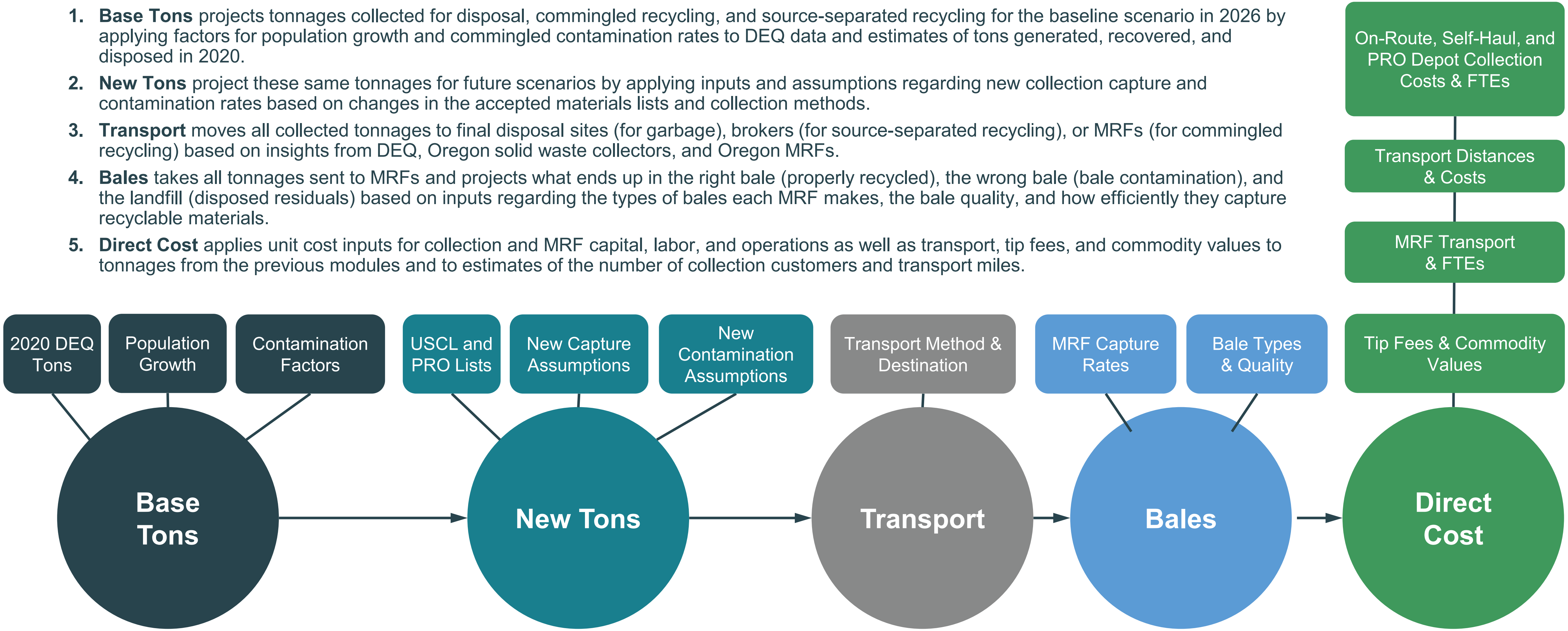
Model Overview

An overview of the tonnage and direct cost model

Scenario Modeling Modules: Tonnages and Direct Costs

The tonnage and direct cost model was built in Excel with five sequential modules that project different parts of the solid waste system.

1. **Base Tons** projects tonnages collected for disposal, commingled recycling, and source-separated recycling for the baseline scenario in 2026 by applying factors for population growth and commingled contamination rates to DEQ data and estimates of tons generated, recovered, and disposed in 2020.
2. **New Tons** project these same tonnages for future scenarios by applying inputs and assumptions regarding new collection capture and contamination rates based on changes in the accepted materials lists and collection methods.
3. **Transport** moves all collected tonnages to final disposal sites (for garbage), brokers (for source-separated recycling), or MRFs (for commingled recycling) based on insights from DEQ, Oregon solid waste collectors, and Oregon MRFs.
4. **Bales** takes all tonnages sent to MRFs and projects what ends up in the right bale (properly recycled), the wrong bale (bale contamination), and the landfill (disposed residuals) based on inputs regarding the types of bales each MRF makes, the bale quality, and how efficiently they capture recyclable materials.
5. **Direct Cost** applies unit cost inputs for collection and MRF capital, labor, and operations as well as transport, tip fees, and commodity values to tonnages from the previous modules and to estimates of the number of collection customers and transport miles.



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Model outputs and limitations

MODEL OUTPUTS

This model outputs scenario profiles and comparisons that let DEQ forecast the impact of investments and policies in terms of:

- Direct costs
- Tons of materials properly recycled

MODEL LIMITATIONS

These models are the best available forecasting tools, but their ability to predict the future is limited by the available input data:

- Historical data on tonnages, recovery rates, costs, and customers
- Current data on markets and technology that constantly and rapidly change
- Limited data on contamination rates in collected commingled recycling and bales sold to market
- Limited data on waste generator responses to changes in the recycling system

While the models may not predict the exact recycling capture rate and costs of a future system in Oregon, we are confident that the results provide reliable directional information for comparing scenarios to inform policy decision regarding the accepted materials lists for the USCL and PRO depots.

DEQ used outputs from the tonnage and direct cost module to estimate indirect costs using DEQ's Waste Impact Calculator and to address uncertainty in estimates. Appendix C provides the indirect cost modeling methodology and a discussion of uncertainty.

TYPES OF DIRECT COSTS INCLUDED IN THE MODEL

Direct Costs	
Recycling education	
Included: • Spending by solid waste collection companies. • Spending by local governments (by including the surcharges on tip fees that pay for them).	**Not included:** • Spending by community organizations.
Collection and transfer/transport	
Included: • Spending by garbage and recycling collection companies, transfer stations, and other regulated facilities to collect materials from generators, consolidate them, and transfer them to a processing or disposal facility. • Estimated cost to drive to PRO depots.	**Not included:** • Estimated value of time for waste generators to sort recyclables.
Disposal and processing	
Included: • Spending by transfer stations and landfills (from tip fees). • Spending by MRFs, based on estimated costs for capital equipment, labor, facility and operations, transfer to secondary MRF, and residual disposal. • Revenues for marketed materials, based on estimated commodity values.	**Not included:** • Spending to transport baled materials to the end-market

Materials in and out of scope for scenario modeling

Scenario modeling doesn't include all waste generated in Oregon. This slide shows what is include and excluded.

INCLUDED MATERIALS

- ✓ **Recycling and garbage regulated by local governments**
- ✓ **Franchised, licensed, or permitted collection for:**
  - Single-family residential
  - Multifamily residential
  - Commercial
- ✓ **Self-haul by the public**
- ✓ **Solid waste / recycling depots**

EXCLUDED MATERIALS (everything else*)

- ✗ **C&D Debris**
- ✗ **Hazardous waste**
- ✗ **Tires, paint, e-waste, etc.**
- ✗ **Organics**
- ✗ **Motor oil**
- ✗ **Bottle Bill recovery**
- ✗ **Commercial recovery not regulated by local government** (e.g., compacted cardboard directly marketed by business, industrial plastic scrap recovery, private scrap metal recycling)
- ✗ **Litter and illegal dumping**

** Most scenarios do not change out-of-scope tons.*

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Geographic areas used in the model

The tonnage and direct cost model divides Oregon into four geographic groupings based on current access to curbside recycling and location.

Group 1 – Metro Area	Group 2 – Willamette Valley, etc.	Group 3 – Other Areas With Curbside Recycling	Group 4 – Areas Without Curbside Recycling
All areas within the Metro urban growth boundary.	Areas with curbside collection in most of the Willamette Valley, the Oregon Coast south to Lincoln County, Deschutes County, Hood River County, and Wasco County.	All other areas with curbside collection, including some small towns from areas in Category 2 if they are distant from Portland and other population centers, such as the City of Oakridge in Lane County.	Areas currently without curbside collection or minimal curbside collection — served mainly by depots, if at all. Some portion of these areas gain curbside recycling in future scenarios.

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Data sources for tonnage and direct cost modeling

BASELINE TONNAGE DATA

- Historic and baseline data on tonnages disposed and recovered by material type, generating sector, and geographic grouping from DEQ's waste characterization studies, DEQ's annual recovery reports, and the consultant's prior modeling for DEQ.
- Population data and projections for 2015-2025 from Portland State University.
- Baseline commingled recycling contamination from studies conducted in and for Metro on single-family (2015 and 2020), multifamily (2017), and commercial (2020) recycling.

SCENARIO COLLECTED TONNAGE INPUTS

- Current collection capture rates for materials accepted in Metro, or Oregon-specific collection capture rates for similar materials.
- On-route capture rates for commingled materials from the City of Seattle.
- Glass collection or capture rates for on-route and/or depot collection from Rogue Disposal and Recycling, and the cities of Beaverton, Hillsboro, and Tacoma (WA).
- Contamination reduction based on customer engagement research conducted in 2020 for Oregon's Recycling Steering Committee and additional data from consultant projects.

SCENARIO MRF PROCESSING TONNAGE INPUTS

- MRF capture rates and bale contamination rates were developed based on publicly available and confidential information from MRF operators in and outside Oregon, MRF equipment manufacturers, and consultant expertise from past MRF studies.

DIRECT COST DATA

On-route and solid waste depot collection costs (see slide 14 for more details)
Data from collectors and local governments in Oregon representing:

- **Group 1:** 222,208 residential and 4,974 commercial/multifamily customers.
- **Group 2:** 112,340 residential and 6,899 commercial/multifamily customers.
- **Group 3:** 3 counties and 1 coastal city with 27k RES and 923 COM/MF accounts.
- **Group 4:** Tillamook County excluding the City of Tillamook.
- **Depot recycling:** 41 depots around Oregon.

PRO depot costs:

- **Capital costs:** building lease rates researched by Metro and from Loopnet.com, industry costs for collection containers
- **Solid waste site improvements:** Lane County transfer stations
- **Labor costs:** OBRC job postings
- **Operating costs**: incentives paid by RecycleBC to PRO depot operators, plus cost estimates for aerosol draining from DeSpray Environmental and cost and operational inputs for EPS densification from Tillamook County and Intco Recycling (maker of GreenMax densifier equipment).
- **User driving:** DEQ survey of recycling specialists on user trips per year, surveys of more than 800 depot users at 19 depots, and IRS federal mileage rate

Transport costs: combination of actual haul costs from collectors plus rate quotes from trucking companies

Sortation costs: Based on publicly available and confidential information from MRF operators in and outside Oregon, equipment manufacturers, LeadPoint, and consultant expertise.

Commodity values: publicly available data, such as RecyclingMarkets.net

Scenario Concepts

Overview of the scenarios included in the modeling

Scenario overview

SELECTING SCENARIO CONCEPTS

What is a scenario? A “scenario” is a unique combination of variables:

- Materials accepted by Local Governments, on the Uniform Statewide Collection List (commingled list) and at PRO depots
- Mode of collection for glass
- Number and type of PRO depots
- Customer engagement efforts to reduce contamination
- MRF equipment, labor, and bale types
- End markets

DEVELOPING SCENARIOS

DEQ developed scenario concepts in several stages:

- **Baseline scenario (S00)**
  The baseline scenario reflects the current garbage and recycling system, including baseline levels of inbound and outbound contamination in commingled recycling and end-markets for marketed materials.
- **20 exploratory scenarios (S01-S20)**
  To provide insight on anticipated policy questions and inform recommendations, in March 2022 DEQ developed several scenario concepts to explore a range of possible approaches and the impacts of step-wise changes in single variables. Compared to the baseline, all future scenarios include additional contamination reduction efforts, additional on-route recycling customers in some areas that lack on-route service, upgraded MRF designs to achieve higher quality bales, and responsible end markets. As a result, comparing future scenarios against the baseline reflects changes more than just the accepted materials lists.
- **28 December 2022 rule concept scenarios (S21-S24)**
  After reviewing results from S01-S20, DEQ defined four additional scenario concepts to inform December rule concepts (for Jan. 11, 2023 Rule Advisory Committee meeting). These scenario concepts also added an “unders recovery system” to MRFs designed to capture more undersized items that would otherwise be lost to residuals. As a result, comparisons against S01-S20 reflect more changes than just the accepted materials list and PRO depots.
- **“Zero Recycling” scenario (S25)**
  This scenario reflects no "in scope" recycling happening in Oregon and was designed to inform DEQ's rule concept on "practicability" (associated with DEQ's language around "responsible end markets").

Note: Limited analysis of additional scenarios is possible and may be conducted if the final rules deviate significantly from the December 2022 rule concepts.

Scenario Overview

69 MATERIALS (GROUPED)

CORE USCL

Glass

PET, HDPE, PP tubs

PET clamshells (thermoforms)

Polycoat cartons & cups

HDPE, PP, PET pails & cups

Rigid PS, other food serviceware

Aerosols

Bulky HDPE, PP products

Lids & film

Aluminum foil & foil products

Shredded paper

Block EPS

Propane canisters

4 COLLECTION METHODS

USCL
commingled collected on-route and at depots

OTS
glass collected on-the-side (on-route)

PRO depot
producer-funded depots collecting several materials

On-the-side and PRO depots
collected on-the-side and/or through producer-funded depots collecting several materials

3 DEPOT DENSITIES

PRO High
Highest number of depot locations

PRO Medium
Medium number of depot locations

PRO Low
Lowest number of depot locations

Material Categories Expanded

CORE USCL

- Recyclable OCC & Kraft paper
- Office paper, printing/writing paper, newsprint, magazines, phone books, paperback books
- Non-polycoated paperboard and molded pulp (excluding food serviceware), e.g., cracker boxes and egg cartons
- Packaging tissue paper and non-metalized gift wrap
- Aluminum/steel cans and small scrap metal
- PET, HDPE, and PP bottles and jars

Excludes items less than 6 ounces or 3” in two directions

Glass

- Bottles and jars

PET, HDPE, PP tubs

- Tubs
- Excludes food serviceware

PET clamshells (thermoforms)

Polycoat cartons & cups

HDPE, PP, PET pails & cups

- Pails and buckets 2-5 gallons
- Nursery containers
- Clear cups
- LDPE bottles and tubs

Rigid PS, other food serviceware

- LDPE and PS nursery containers
- PS packaging and cups
- PP & PET food serviceware (excluding cups)

Aerosol cans (empty)

Bulky HDPE, PP products

Lids & film

- Tub and container lids
- HDPE 6-pack carriers
- PE film/wrap

Aluminum foil & pressed foil products

Shredded paper

Block EPS foam

Propane canisters

ACRONYMS

EPS	Expanded polystyrene (foam)
HDPE	High-density polyethylene (resin code #2)
LDPE	Low-density polyethylene (resin code #4)
OCC	Old corrugated cardboard/containers
PET	Polyethylene terephthalate (resin code #1)
PP	Polypropylene (resin code #5)
PS	Polystyrene (resin code #6)
USCL	All materials on Oregon’s uniform statewide collection list

Overview of modeled scenarios

KEY@

- Commingled in USCL
- On the side
- On the side in Grouping 1 & PRO depot in Groupings 2-4
- PRO depots – medium density
- PRO depots – low density
- PRO depots – high density
- Not accepted
- Varies by grouping

Notes:

- S18: glass is collected only in a dedicated glass-only truck
- S19: glass is collected only in a compartment on the side of the commingled truck
- S20: less glass is available curbside because the Bottle Bill is expanded

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Types of PRO Depots

This section describes the number and type of PRO depots modeled in future scenarios.

PRO depot modeling includes four types of PRO depots:

CO-COLLECTION AT EXISTING RECYCLING DEPOTS

- Expanded recycling areas at transfer stations, solid waste collector sites, and other permitted solid waste facilities that already accept drop-off recycling
- Collect all covered materials designated for recycling

RETURN-TO-RETAIL

- Containers for individual materials or accepted mixed rigid plastics added <u>inside</u> retail stores to collect PRO depot materials
- Collect an average of two covered materials

SINGLE-MATERIAL DROP-BOX

- Drop-box containers for individual materials or accepted mixed rigid plastics added <u>in parking lots</u> at retail stores, community organization, or other frequently visited sites
- Collect one covered material

NEW MULTI-MATERIAL DEPOTS

- Stand-alone or strip-mall "stores" dedicated to accepting the full range of PRO materials
- Collect all covered materials

DEPOT COUNTS

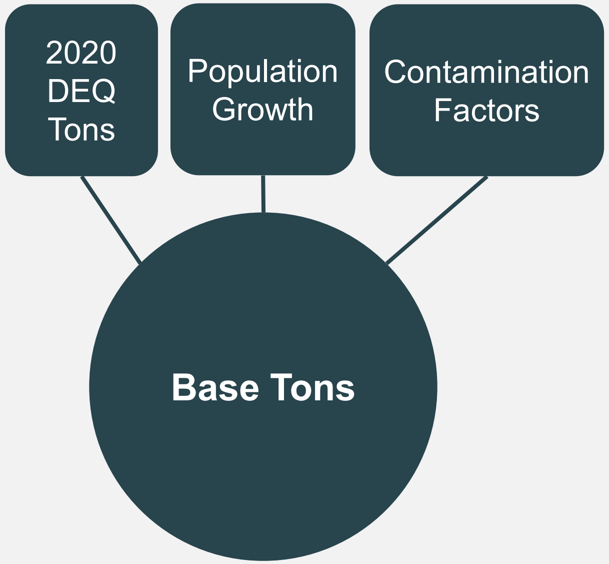
Depot counts by type for each scenario were provided by DEQ with consideration for:

- Depot density requirements
- Number of return-to-retail and single-material depots that do not collect all covered materials

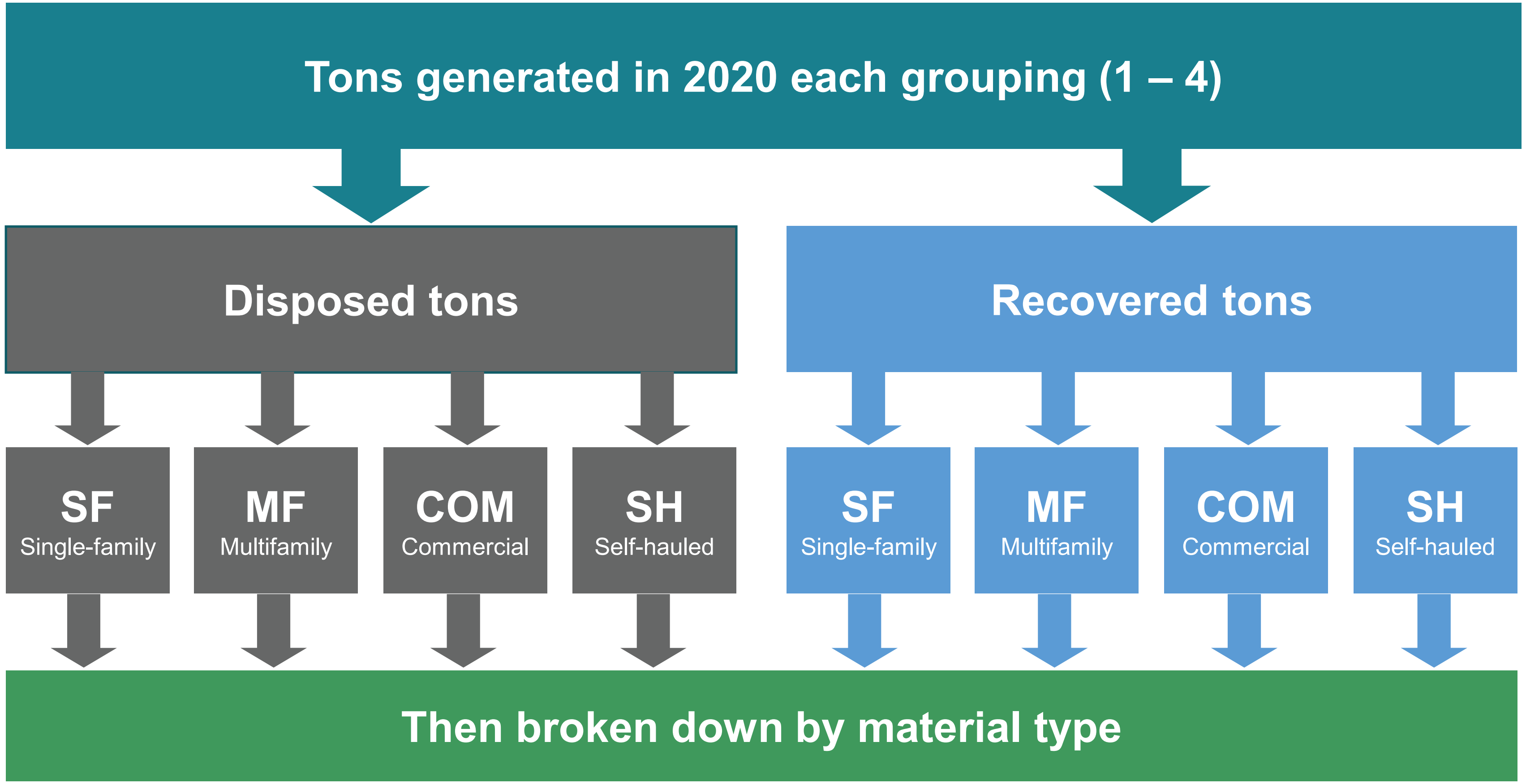
Depot counts by scenario, depot type, and grouping can be found in the COST module.

Baseline Tons

Estimating tonnages for the baseline scenario in 2026



The BASE TONS module starts with detailed estimates from DEQ on the tons in 2020 disposed and recovered by grouping, sector, and material type.



Source: 2020 tons by grouping, sector, and material from Oregon DEQ

Growing 2020 Tons to 2026 using population growth

The BASE TONS module then grows the tons from 2020 to estimate tons in 2026 based on projected population growth using the steps shown here.

The baseline projections assume no changes to the recycling system or recycling rates. The current system is frozen and transported "as is" to 2026, growing only to handle the additional population.

Growth factors use an average of tons per capita in 2017 and 2020 because more recent data (2020) are usually more accurate, but the COVID-19 pandemic dramatically shifted where and how much was generated. Data from 2017, previously modeled for DEQ, were incorporated into the baseline to moderate this temporary impact.

Step 1. Calculate historic waste generated per capita.

Tons per capita 2017 ÷ 2 + Tons per capita 2020 ÷ 2 = Average tons per capita

Step 2. Use historic average per capita and projected population to estimate 2026 total tons generated

Average tons per capita × Population in 2026 = 2026 tons by grouping & sector

Step 3. Apply 2020 composition of waste and recycling to projected 2026 total tons.

1. In Grouping 2, single-family residents are projected to generate **485,290 tons** in 2026
2. In 2020, **6.17%** of their total generation was cardboard placed in commingled recycling.
3. So, in the 2026 baseline, we project they will send **29,961** tons (6.17% of 485,290 tons) of cardboard to commingled recycling.

Sources: 2017 tons from previous modeling for Oregon DEQ. Population data and projections from Portland State University (PDX)

Estimating Contamination and Tons Collected

Disposed (from DEQ)

Contamination (Metro studies)

Recovered/ Marketed (from DEQ)

Disposed (from DEQ)

Contamination (Metro studies)

Recovered/ Marketed (from DEQ)

Collected for disposal = Disposed - Contamination

Collected for recycling = Recovered + Contamination

Data from DEQ on tons disposed and recovered represented tonnages after MRF sortation, so the recycling tons did not include contamination in commingled collection. Those contamination tons were in disposal.

To develop the baseline tons that represented collected materials in commingled recycling carts – including the contamination – we used studies from Metro to estimate inbound contamination rates overall and by material. Baseline rates were:

- Single-family: 13.8%
- Multifamily: 21.1%
- Commercial: 13.4%
- Self-haul: 13.8%

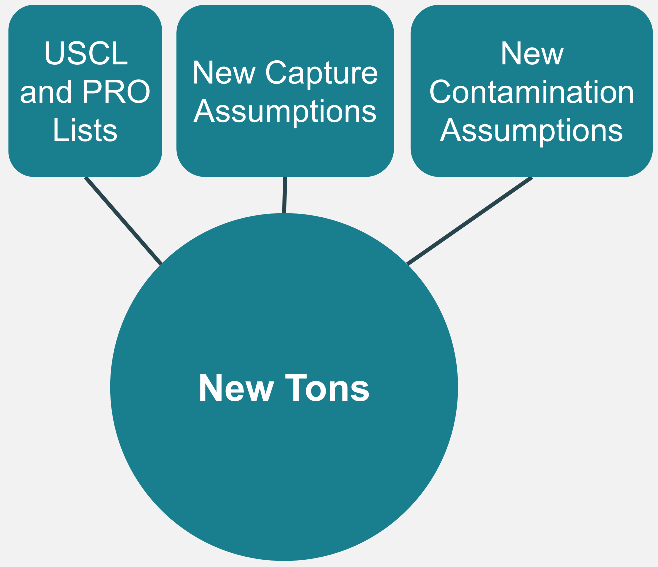
We then moved that contamination from disposal tonnages into recycling tonnages.

Sources: recycling contamination studies for single-family (2015 and 2020), multifamily (2017), and commercial (2020) for and in Metro.

Commingled Collection Tons

New collection capture and contamination rates for USCL (Uniform Statewide Collection List) materials

Estimating Collection Capture Rates for New USCL materials



The NEW TONS module takes tons from the BASE TONS module and applies inputs and assumptions to project future collected tons by grouping, sector, collection method, and material. It projects:

- Capture rates for materials on the USCL and PRO depot lists
- Contamination rates for materials collected as commingled recycling.

This section describes how the model estimated:

- Collection capture rates for USCL materials that were not previously accepted either in individual groupings or anywhere in Oregon.
- The reduction in commingled contamination rates by material type for future scenarios resulting from additional generator-facing engagement.

New Capture Rates for USCL

MATERIALS THAT METRO CURRENTLY RECYCLES

A capture rate is the percentage of a material generated that is captured for recycling. For example, the single-family residential capture for polypropylene (PP) tubs in Metro is 50%.

To estimate capture rates for materials that are currently recycled in Metro (Grouping 1), the model:

- Starts with Metro's baseline capture rate for that material and that sector.
    - This capture rate is used in Metro.
- Adjusts that captures for Grouping 2-3 based on how much those groupings recycle at baseline compared to Metro for materials recycled everywhere.
    - These adjustment were developed by evaluating the ratio of the capture rate for steel cans for Metro compared to the affected grouping.
    - Other reference materials were considered but not used because:
        - Plastics are not collected universally
        - Many bottles and cans are covered by the Bottle Bill
        - In rural areas, paper is more commonly used in wood stoves.
    - For materials where the baseline capture rate for Grouping 2-3 was higher than for Metro, the model uses the grouping's baseline rate.
- Capture rates for Grouping 4 are further reduced because in the model only 30% of customers gain recycling.

EXAMPLE

The table below shows adjustment factors used in the model.

Grouping	**SINGLE-FAMILY** Compared to Metro SF*	**MULTIFAMILY** Compared to Metro MF*	**COMMERCIAL** Compared to Metro COM*	**SELF-HAUL** Compared to Metro SF*
1	100%	100%	100%	100%
2	74%	26%	67%	30%
3	33%	6%	24%	10%
4	10%	2%	9%	NA**

*Override with baseline capture rate if the grouping recycles better than Metro
** Used 100% of baseline capture rates for Grouping 4 self-haul.

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Example for New Capture Rate

Below is an example of how USCL collection capture rates for PP tubs were estimated for single-family (SF) residents in Grouping 2.

- The baseline capture rate for PP tubs from single-family residents in Metro (Grouping 1) is 50%. This means that in baseline conditions, single-family residents (who all have on-route recycling that accepts PP tubs) recycle 50% of the materials available to them.
- The adjustment factor for single-family residents in Grouping 2 is 74%.

Grouping 1
Capture Rate for PP+HDPE Tubs

50%

×

Grouping 2
Recycling behavior compared to Grouping 1

74%

=

Grouping 2
USCL capture rate for PP+HDPE Tubs

37%

Grouping 1 SF's capture rate for PP+HDPE Tubs is 50%

→

Grouping 2 SF recycles 74% as well as Grouping 1 SF

Another way to think about it

If Grouping 1 is recycling
50 lbs out of 100 lbs of tubs

Then Grouping 2 would recycle 37 lbs out of 100 lbs of tubs.

New Capture Rates for USCL

FOR OTHER MATERIALS NOT ACCEPTED IN METRO

Some materials are not currently collected in commingled recycling in Oregon. To develop capture rates for these materials, the model:

- Uses a similar material that is already recycled in Metro
    - Combination of HDPE+PP tubs (6 oz to 2 gallons), which DEQ projects has the same capture rate (50%)
- Further adjust the capture by comparing capture rates by Seattle residents for the new and standard materials.
    - Many of the new materials added to the USCL are already accepted for commingled recycling in Seattle.

EXAMPLES

Below is an example for how capture rates were developed for a material not currently accepted in Metro's commingled recycling:

- Trays, other clamshells, and other rigid plastic containers not currently accepted curbside
    - The model assumes that people will recycle this material at three-quarters the capture rate (75%) that they recycle tubs 6 oz to 2 gallons.
    - This ratio (75%) is based on Seattle capture rate data for plastic food service ware compared to non-bottle PP and HDPE packaging (combined).

Example Capture Rate for New Materials

Continuing the example from before, below is an example of how USCL collection capture rates were developed for trays, clamshells, and other RPCs not currently accepted at curbside collected from single-family (SF) residents in Grouping 2.

- The projected capture rate for tubs is multiplied by 75%, which is the adjustment factor for trays, clamshell, and other RPCs not currently accepted at curbside.

Grouping 1
Capture Rate for PP+HDPE Tubs

50%

×

Grouping 2
Recycling behavior compared to Grouping 1

74%

×

Recycling behavior for trays compared to tubs

75%

=

Grouping 2
USCL capture rate for trays and clamshells

28%

Grouping 1 SF's capture rate for PP+HPDE Tubs is 50%

→ Grouping 2 SF recycles 74% as well as Grouping 1 SF

→ Estimate people recycle Trays, etc. 75% as well as they recycle PP+HDPE Tubs (Seattle)

Another way to think about it

If Grouping 2 would recycle
37 lbs out of 100 lbs of tubs

Then Grouping 2 would recycle
28 lbs out of 100 lbs of trays, etc.

Contamination Reduction in Commingled

The Act requires the PRO to fund contamination reduction programming at a rate of $3 per Oregon resident per year. Local governments are required to implement programming to reduce contamination including outreach, feedback, targeted enforcement, and periodic evaluation. In addition, the Act requires tot PRO to provide additional outreach and educational materials. As a result, the model reduces contamination rates in in-bound recycling using available information drawn from evaluated pilot projects. Contamination reductions vary by:

Sector – highest for single-family and lowest for commercial.

Material – higher for materials that are easy to communicate – like film, foam, and food – and lower for confusing materials like mixed plastic packaging.

Contamination Type	Single-family and Self-haul	Multifamily	Commercial
Film and Foam	**75%**	**50%**	**15%**
Food	**75%**	**50%**	**15%**
Other materials	**40%**	**25%**	**15%**

The table reflects reduction factors used for most materials for commingled materials in S01-S05.

Reduction factors also vary by scenario. Despite a lack of data showing a consistent impact of a longer list on contamination, the model uses the assumption people are more likely to put unwanted materials in commingled recycling when:

- The USCL list is longer
- A material is accepted at PRO depots

Similarly, the model also assumes that moving glass to depots only counteracts engagement, so glass contamination does not reduce in glass-depot scenarios

The NEW TONS module contains the specific reduction factors by contamination type, sector, and scenario.

Contamination Reduction Data Sources

The following studies were considered when developing contamination reduction inputs.

Method	Jurisdiction	Results
Feedback only	Clackamas County, OR	-32% carts receiving second tag
	Chicago, IL	-32% contamination
Campaign-based refusal	Atlanta, GA	-57% contamination
	Lowell & W. Springfield, MA	-30% contamination
	Snohomish County, WA	-64% carts receiving second tag
Ongoing refusal	Greensboro, NC	-87% carts receiving second tag, -98% third tag
	Albuquerque, NM	-84% carts receiving second tag, -96% third tag
Driver-based refusal + simpler list + more	Rogue Disposal & Recycling, OR	-72% "garbage" contamination* -58% overall contamination* -85% tags distributed
Refusal -- unspecified	21 Massachusetts municipalities	-45% to -85% carts tagged (18 cities) -21% to -33% carts tagged (3 cities)
	Sanford, ME	-80% contamination (or more)

* "Garbage" contamination measures materials that Rogue never accepted. "Overall" also includes materials previously accepted for recycling but that were removed from the accepted list when Rogue simplified it.

Further information on contamination reduction efforts can be found in the Customer Engagement Research Summary developed by Cascadia for DEQ's Recycling Steering Committee in 2020 at www.oregon.gov/deq/recycling/Documents/rsc-022820CustEngagementResearch.pdf

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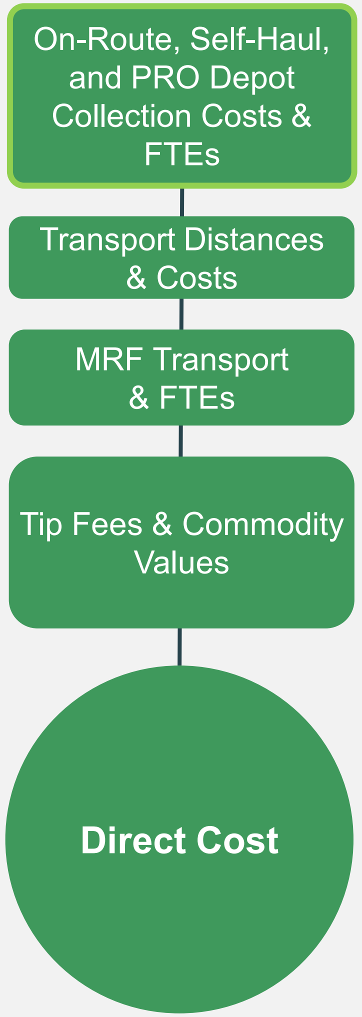
On-Route and Solid Waste Site Collection Costs

Modeling direct costs for the system: On-Route and Solid Waste Depot Collection



This section describes how costs were developed for on-route (commingled) collection and for existing depot collection at existing self-haul facilities. Costs for PRO depots are described in a later section.

Collection cost data sources for on-route and solid waste facility recycling depots

The direct cost module used data from collectors and local governments in Oregon:

- **Grouping 1:** 222,208 residential and 4,974 commercial/multifamily customers
- **Grouping 2:** 112,340 residential and 6,899 commercial/multifamily customers.
- **Grouping 3:** 3 counties and 1 coastal city with 27,018 residential and 923 commercial/multifamily customers.
- **Grouping 4:** Tillamook County excluding the City of Tillamook.
- **Solid waste depot recycling:** 41 depots around Oregon

Collection costs for scenarios with dramatically different collection systems, such as changing the types of trucks that collect glass or eliminating recycling, were developed using the data listed above, additional confidential information from collectors in different systems and from truck manufacturers regarding route collection efficiency and truck costs.

The model also separately estimates full-time equivalent employees for on-route and solid waste depot collection.

On-Route and Solid Waste Depot Collection Costs

ON-ROUTE COST PER PICK-UP

- Driver labor and benefits
- Container and truck capital costs
- Route operations and other direct costs

Multiply by est. number of customers or by pick-up/lifts per year

ANNUAL COSTS PER CUSTOMER

- Administrative costs
- Customer engagement
- Profit margin and franchise fee

Multiply by est. number of customers

Customer counts
- Ratio of customers by type to population served.
- Data from DEQ and haulers on curbside collection service provided to each area.

SOLID WASTE DEPOT RECYCLING:
TOTAL COST PER RECYCLING TON COLLECTED

- Total cost per recycling ton collected
- Cost allocations (percentages) for:
    - Labor
    - Capital
    - Operations
    - Transport
    - Administrative

Multiply by number of recycling tons collected (excluding metal)

SELF-HAUL GARBAGE COSTS

- Estimated using disposal tip fees.

How on-route collection costs change as tonnages change
- Collection labor, truck, and operations unit costs are adjusted by comparing pounds collected per customer for the future scenario to tons collect in the baseline.
- Based on data from haulers, for every 10% change in tons, unit costs change by 9%.
    - If commingled tons increase by 10%, commingled collection unit costs increase by 9%.
    - If garbage tons decrease by 10%, garbage collection unit costs decrease by 9%.

PRO Depot Collection: Concepts and Capture Rates

Total Number of PRO Depots

Formula	Low Density	Medium Density	High Density
Every county has at least 1 PRO depot . . .	1	1	1
. . . plus one additional PRO depot for every X people, rounded up	X = 75,000 (Metro) X = 50,000 (others)	X = 60,000 (Metro) X = 40,000 (others)	X = 45,000 (Metro) X = 30,000 (others)
Every city with a population over M has at least 1 PRO depot (this depot also counts toward meeting the County standard . . .	M = 20,000 (Metro) M = 10,000 (others)	M = 15,000 (Metro) M = 7,500 (others)	M = 10,000 (Metro) M = 5,000 (others)
. . . plus one additional PRO depot for every Y people, rounded up	Y = 100,000 (Metro) Y = 40,000 (others)	Y = 75,000 (Metro) Y = 35,000 (others)	Y = 50,000 (Metro) Y = 30,000 (others)
Number of Sites			
Grouping 1 (Metro)	24	29	39
Grouping 2 (“Willamette Valley”)	36	52	58
Grouping 3 (“Other Curbside”)	14	33	47
Grouping 4 (Rest of State)	14	32	38
TOTAL	**88**	**146**	**182**

EXAMPLES:
- In the low-density scenario, a non-Metro county with a population of 60,000 would get two sites. One because it’s a county and a second because it has more than 50,000 people.
- If that county also had three cities that each had a population of 10,001, the county would get three sites total (one per city), and two of those sites would also fulfill the county-level requirements

The formulas above represent PRO depot counts for Scenarios S06-S15 and S17. DEQ changed density assumptions slight for Scenarios S21-S24.

NOTE: The Act and DEQ's rule concept requires the PRO to give existing permitted solid waste disposal sites the opportunity to participate, within the number of required PRO depot sites. The low scenario requires fewer PRO depot sites than the current number of solid waste sites, so assumes that not every existing depot will choose to expand.

New Capture Rates for PRO Depots

PRO depot capture rates were developed by comparing capture rates for depot versus on-route collection for glass recycling, including the number of depots and populations in reference jurisdictions that collect glass using depots only.

Groupings – Data and Calculation Approach

Grouping 1: City of Tacoma Data

- After switching to depot-only glass with 1 depot for every 43,000 people, Tacoma kept collecting 77% of tons collected previously curbside collection.

Grouping 2: Rogue Disposal & Recycling Data

- Rogue Disposal and Recycling collects glass using depots only (1 depot for every 25,000 people) and collects an average of 84% of on-route glass per customer compared to on-route service in Eugene and Hillsboro.

Grouping 3: Calculation

- Average of Groupings 2 and 4, shown below

Grouping 4: Estimation

- The grouping-wide capture rate in Grouping 4 was approximately 20% compared to Grouping 1 for steel cans and other [non-deposit] container glass

DENSITY ADJUSTMENT

Depot capture rates from the reference jurisdictions were adjusted among the high, medium, and low scenarios based on the required number of depot sites per population using the following assumptions:

- **Doubling depots** increases capture rate increases by half (50% higher).
- **Halving depots** decreases capture rate by half the half (or 25%).

Grouping	High	Medium	Low
1	81%	70%	64%
2	83%	79%	67%
3	51%	48%	42%
4	20%	18%	16%

The following slide shows an example, calculating the capture rate for trays, clamshells, and other rigid plastic containers not currently accepted at curbside from Single-Family residents in Grouping 2. It continues the example started in the description of calculating capture rates for USCL materials.

Example for PRO Depot Capture Rate

This slide continues the example from estimating the capture rate for commingled, on-route collection for trays, clamshells, and other rigid plastic containers not currently accepted at curbside from Single-Family residents in Grouping 2.

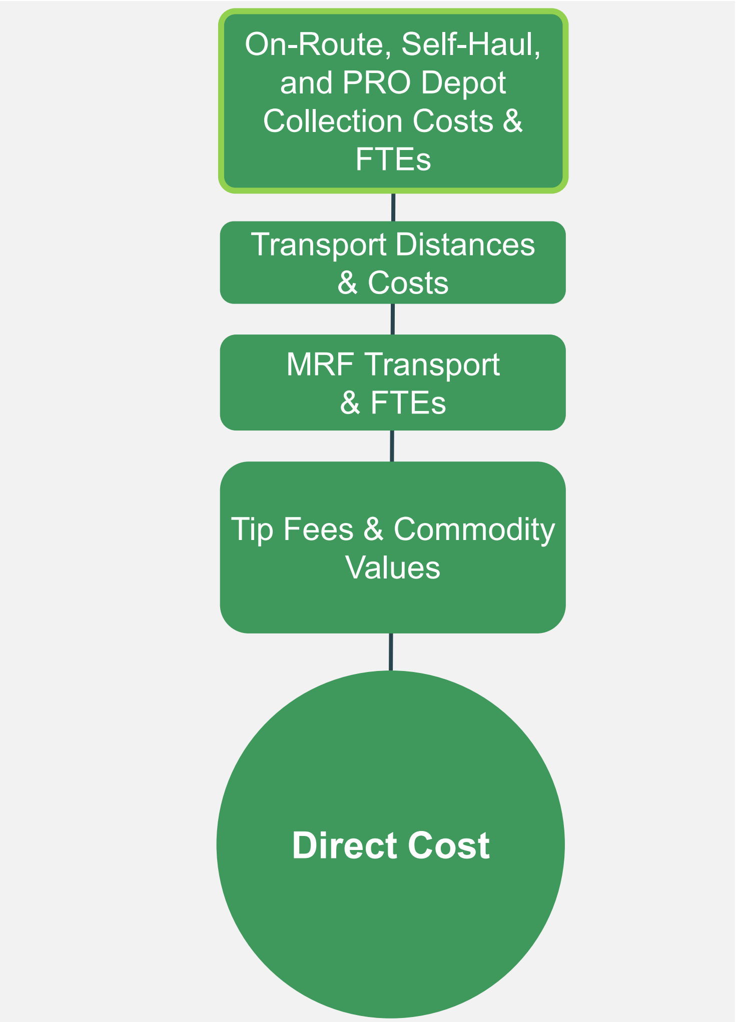
Grouping 1 Capture Rate for PP+HDPE Tubs		Grouping 2 recycling behavior compared to Grouping 1		Trays recycling behavior compared to PP+HDPE Tubs		Recycling at high density depots compared to on-route in Grouping 2		PRO depot capture rate for trays, etc. in Grouping 2 SF
50%	×	74%	×	75%	×	83%	=	23%
Grouping 1 SF's capture rate for PP+HDPE Tubs is 50%	→	Grouping 2 SF recycles 74% as well as Grouping 1 SF	→	Estimate people recycle Trays, etc. 60% as well as they recycle PP+HDPE Tubs (Seattle)	→	Estimate high density depots in Grouping 2 capture 83% of what would be collected on-route		

Another way to think about it

If Grouping 2 would recycle 28 lbs. out of 100 lbs. of trays at curbside
Then Grouping 2 would recycle 23 lbs. out of 100 lbs. of trays, etc. at PRO depots

PRO Depot Collection: Costs

Modeling direct costs for the system: PRO Depot Collection



This section describes how costs were estimated for PRO depots. PRO depot costs include:

SITE AND CAPITAL COSTS

- Property lease: Building lease rates researched by Metro and gathered from Loopnet.com
- Site improvement for co-collection and multi-material depot: Data from Lane County transfer stations, consultant estimate
- Containers: industry costs for collection containers

LABOR COSTS

- Hourly labor rates. OBRC job postings
- FTE (full-time equivalent employees) per site: consultant estimate

COLLECTION AND SPECIAL PROCESSING COSTS

- Collection operations costs: Based on 2022 compensation rates paid by RecycleBC to PRO depots, converted to US dollars and short tons
- Densification of EPS: Data and equipment specifications from GreenMax (Intco Recycling) and Tillamook County. Includes capital costs (stored in MRF capital cost tab) and operating costs per ton.
- Aerosol draining: Costs estimate from DeSpray Environmental for operating cost per ton and capital cost.

OTHER COSTS:

- Administrative costs: Consultant estimate for additional staff time spent contracting with PRO, reporting, and personnel/management.
- Miscellaneous operations: Consultant estimate of cost per ton collected for miscellaneous costs for office supplies, signage, cleaning, etc.

PRO Depot Capital Costs – Property Lease and Site Improvements

This section summarizes key inputs use to estimate property- and building-related costs for PRO depots. They are calculated per site and vary based on the number and type of PRO depots in each scenario.

Depot Type	Size	Space Type
Co-collection at Existing Depots	1,200 sq. ft.	Industrial
Return-to-Retail	100 sq. ft.	Retail
Single-material Dropbox	200 sq. ft.	Retail
Multi-material Depot	1,200 sq. ft.	Retail

Grouping	Monthly cost per square foot for retail space	Monthly cost per square foot for industrial space
Grouping 1 (Metro)	$2.33	$2.15
Grouping 2 ("Willamette Valley")	$2.08	$1.69
Grouping 3 ("Other Curbside")	$1.97	$1.56
Grouping 4 (Rest of State)	$1.61	$1.56

SITE IMPROVEMENT ANNUAL COSTS
(assuming a 10-year depreciation)

Co-collection at existing depots:
$3,239

Multi-material depot:
$10,000

ASSUMPTIONS

- Building lease rates in Metro researched by Metro
- Building lease rates for Metro and other areas gathered from Loopnet.com and compared to lease rates researched by Metro
- Depot sizes based on consultant estimates
- Site improvement for existing depots based on data from Lane County transfer stations

PRO Depot Capital Costs – Containers

This section summarizes key inputs use to estimate container-related capital costs for PRO depots. They are calculated per site and vary based on the number and type of PRO depots in each scenario and on the number of materials accepted for PRO depot recycling.

Depot Type	Container Counts	Cost per Container	Container Notes
Co-collection at Existing Depots	Varies based on PRO depot material list	$155	4-cubic-yard dumpster with 10-year lifespan
Return-to-Retail	Average of 2 per site	$590	Set of five 20-cubic-foot containers with a 3-year lifespan
Single-material Dropbox	Average of 1 per site	$250	User-friendly 4-cubic-yard dumpster with 10-year lifespan
Multi-material Depot	Varies based on PRO depot material list	$155	4-cubic-yard dumpster with 10-year lifespan

PRO Depot Labor Costs

This section summarizes key inputs use to estimate staffing related costs for PRO depots. They are calculated per site and vary based on the number and type of PRO depots in each scenario.

ASSUMPTIONS

- Fully-loaded labor costs based on:
    - Wages in OBRC job postings across the state
    - Approximately 40% additional cost for benefits
- FTEs per site based on consultant estimates

Grouping	Hourly cost at multi-material depots	Hourly cost at other PRO depots
Grouping 1 (Metro) & Grouping 2 (“Willamette Valley”)	$29.96	$27.45
Grouping 3 (“Other Curbside”) & Grouping 4 (Rest of State)	$28.70	$24.93

Depot Type	FTES
Co-collection at Existing Depots	0.25 FTE
Return-to-Retail	0.15 FTE
Single-material Dropbox	0.10 FTE
Multi-material Depot	2.00 FTE

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PRO Depot Collection Operations and Special Processing Costs

This section summarizes key inputs use to estimate material-specific operations and special processing costs for materials collected from PRO depots. They vary per ton of material collected. Sortation costs for mixed plastics are included in MRF processing costs.

ASSUMPTIONS

- Used 2022 compensation rates RecycleBC pays to PRO depots, converted to US dollars and short tons

SPECIAL PROCESSING FOR FOAM AND AEROSOLS

Polystyrene foam, aerosol cans, and other pressurized cylinders require special processing. Operating costs are incorporated into the per-ton costs shown in the table at right. Capital equipment costs are incorporated in the MRF capital equipment tab of the COST module.

- Capital and operating costs for draining aerosols provided by DeSpray Environmental
    - Aerosol draining and recycling system capital cost: $500,000
- For polystyrene foam, added 6 densifiers in the state and added $264/ton to RecycleBC per-ton costs for densification.
    - EPS densifier capital cost: $25,000 each

Material	Per-Ton Cost
Shredded Paper	$170
Cartons and Polycoat Paper	$240
Mixed Plastics	$240
Foil and Foil Containers	$240
Aerosol Cans and Other Pressurized Cylinders	$2,000
Film Plastic	$1,642
Polystyrene Foam	$1,984
Glass	$77

PRO Depot Other Costs – Admin and Miscellaneous Operations

This section summarizes key inputs used to estimate administrative costs (calculated per site) and miscellaneous operations costs (calculated per ton collected).

Depot Type	Annual Admin Cost	Admin hours	Misc. Ops Cost per Ton
Co-collection at Existing Depots	$5,992	• 40 hours of contracting with PRO • 5 reporting hours/month • 0.5 personnel & management hours/week	$5.00
Return-to-Retail	$4,185	• 12 hours of contracting with PRO • 2 reporting hours/month • 1 personnel & management hours/week	$15.00
Single-material Dropbox	$4,185	• 12 hours of contracting with PRO • 2 reporting hours/month • 1 personnel & management hours/week	$7.00
Multi-material Depot	$17,500	• 40 hours of contracting with PRO • 10 reporting hours/month • 4 personnel & management hours/week	$12.00

ASSUMPTIONS

- **Administrative costs:** Consultant estimate for additional staff time spent contracting with PRO, reporting, and personnel/management, using hourly wage from OBRC job posting for Bottle-Drop Field Manager plus 40% benefits cost ($50.40 per hour total).
- **Miscellaneous operations:** Consultant estimate of additional cost per ton collected for things like office and cleaning supplies, safety equipment, small tools, and other miscellaneous items.

Transport: Method and Cost

Transport Costs (after collection)

tons × miles × cost per ton-mile = cost

Transport costs are calculated by multiplying tons transported by distance in miles by the cost per ton-mile.

- Miles and costs per ton-mile are in the COST module
- Tons by source and destination and distributed in the TRANSPORT module

TRANSPORT COST DEVELOPMENT

Developed costs per ton-mile for:

- Different collection streams
  - Commingled
  - Source-separated materials
  - Garbage
  - PRO depots (with additional cost factor when EPS is collected)
  - Transfer from MRF to CRF
  - MRF and CRF residue to disposal
- Different transport methods
  - Walking floor trailer
  - Drop box
  - Box truck
  - And many more…

TRANSPORT COST APPLICATIONS

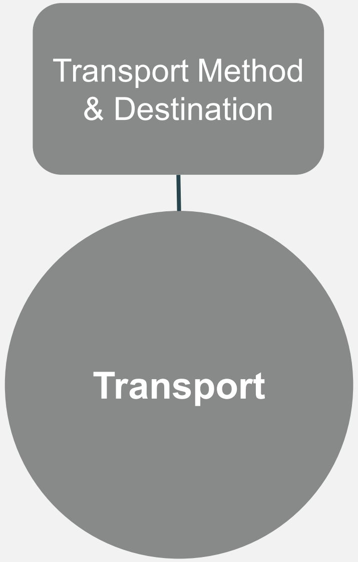
Applied costs per-ton mile to:

- Tons collected from the tonnage model
- Average miles transported by grouping

Data Sources

- Transport cost data generated using actual haul costs from solid waste collectors plus rate quotes from trucking companies, applied to tons transported and miles traveled.
- Transport cost calculations in the COST module were calculated separately for:
  - First transport after collection
  - Transfer for additional processing or residue disposal
  - Depot user transport to depots in private vehicles

Transport Module



Moves collected materials to the MRF, landfill, etc.

The TRANPORT module contains assumptions and calculations for the source, destination, and transport method after collection to the first destination.

From each sector and collection stream in each grouping, such as:

- Single-family glass on-the-side from Grouping 1
- Self-haul commingled recycling from Grouping 2
- Commercial garbage from Grouping 3
- PRO depot recycling from Grouping 4

To up to three destinations each:

- Percentage to each destination
- Destination (e.g., MRF type/location, landfill)
- Transport method (e.g., walking floor trailer, directly delivered in collection vehicle, box truck)

EXAMPLE: 100% of self-haul commingled from Grouping 2 modeled as going to a MRF in Salem by drop-box.

- Destination and method assumptions for the first transport after collection are in the TRANSPORT module. They were developed based on data available from haulers, MRFs, and DEQ.
- The COST module includes cost estimates for transferring materials to other MRFs or the Container Recovery Facility for additional processing and to transport residue to the nearest disposal site, based on outputs from the BALES module.

PRO Depot User Transport – Driving to the Depot

The original direct and indirect cost models from 2020 incorporated the economic and environmental impacts of driving by solid waste collection vehicles. To estimate the impacts of driving to PRO depots, DEQ and Cascadia modeled the “additional miles” that PRO depot users would drive to drop off materials. Mileage estimates were then converted to direct costs using the IRS mileage rate of $0.56 per mile and to indirect costs using emissions data for average passenger vehicles.

To estimate the number of “additional miles” for PRO depot usage in each scenario, Cascadia and DEQ considered the following factors:

- Number of households using the depots. This was estimated as a function of the quantity of materials delivered (scenarios with more depots were assumed to collect more materials, a consequence of more households using the service).
- Number of trips the average household makes per year.
- Average number of miles (round-trip) per trip.
- An “additionality factor” representing the percentage of trip-miles that are “additional” (new trips, or otherwise driven “out of the way” to deliver materials).
    - For example, miles driven to a recycling depot co-located with a garbage transfer station have 0% additionality for those users already delivering garbage but would have 100% additionality for a user who made a dedicated trip with no other stops.

The last three factors used data drawn from multiple sources. DEQ worked with partners to survey more than 800 users of 19 existing recycling depots spanning the state from Astoria to Medford to Wallowa County. This research revealed clear differences in driving behavior and additionality when comparing recycling services co-located with solid waste disposal sites vs. stand-alone depots, which were then applied to scenarios based on the assumed number and type of collection points (e.g., existing depot vs. return-to-retail) for each of the four geographic groupings in the model.

PRO depot user transport miles and direct costs are calculated in the COST module.

Limitations

While survey data provided valuable insight into the behavior of *current* depot users, the types and locations of collection points offered by PROs in *model* scenarios do not presently exist, so user behavior cannot be observed. Most importantly, the materials modeled for collection at these future depots are typically lower in volume or generated less frequently than cardboard, mixed paper, and materials currently collected at depots.

Because it is impossible to predict the future behavior of Oregonians with precision, DEQ assembled a panel of informed professionals who are best positioned to estimate average trips per year and additionality: a panel of more than 20 depot operators, waste collectors, and local government recycling coordinators and public educators who offered their predictions regarding user behavior for a variety of different scenarios, customized to their communities and consistent with underlying modeling inputs regarding depot density and material acceptance. Their input was aggregated according to scenario and geographic grouping and used to predict number of trips and additionality factor for average participants.

Number of Depot Users and Additional Miles Driven

NUMBER OF PRO DEPOT USERS

The number of PRO depot users were calculated based on the highest capture rates for materials recycled at PRO depots using the following formula:

$$Capture\ rate\ = \frac{Participation\ (percentage\ of\ households\ that\ recycle\ a\ material)}{Efficiency\ (how\ well\ those\ households\ recycle\ that\ material)}$$

The model assumes that each participating household is 90% efficient, so participation rates are calculated by dividing the highest capture rate for a PRO depot material by 0.9. Where capture rates were especially high, we limited the maximum participation rate to 90%.

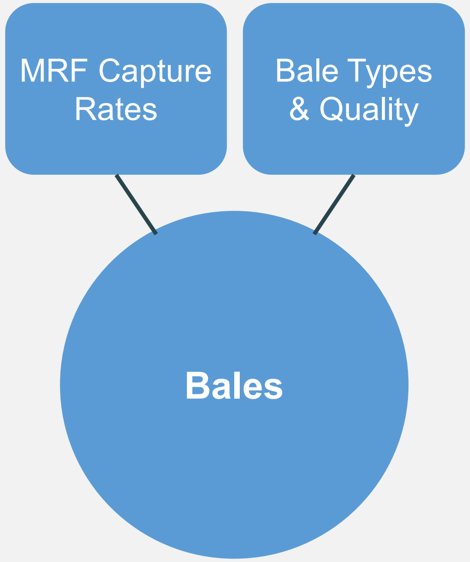
The model calculates the number of participating households by multiplying the participation rate by an estimate of the total number of households in Oregon. Oregon averages 2.49 persons per household, so total households were calculated by dividing the projected population for 2026 by 2.49.

ADDITIONAL MILES DRIVEN

Oregon DEQ developed estimates of trips per user per year, mileage, and the percent of milage due to recycling (i.e., when a user drives extra miles to reach a recycling site) using input from recycling specialists around Oregon. Estimates vary by scenario and grouping. Inputs are in the UserTransport tab of the COST module.

Processing and Disposal

Bales Module



Moves collected materials to the MRF, landfill, etc.

The BALES module declares:

- **Bale types made—**What types of bales each MRF makes (e.g., cartons bale or mixed paper bale)
- **Bale definitions—**What materials are targeted to go into each bale type (e.g., PET bottles into the PET bottle bale)
- **Bale quality—**The contamination rate for each bale type
- **MRF capture rates—**What percentage of targeted materials get into the proper bale (instead of landfilled residue or bale contamination)

The model then takes tonnages collected in USCL and as mixed plastics at PRO depots and performs a lot of calculations:

- Calculates the percentage of each material properly sorted (MRF capture rate)
- Distributes properly sorted tons among the bale types made.
- If needed, transfers materials to a secondary MRF (and re-sorts and re-distributes)
- Adds bale contamination tons, based on declared bale quality.

DATA SOURCES

Inputs developed based on available information about Oregon MRFs, DEQ's goals for MRF efficiency, and consultant experience with MRFs

MRF Upgrade Approach

To achieve the higher capture rates and lower bale contamination rates in future scenarios, the model incorporates upgrades to existing MRFs and a new container recovery facility (CRF) line.

UPGRADE TO MRFs

- Continue using existing technology (robots, opticals) already in the system
- Add technology at all MRFs to improve quality (primarily fiber and metal lines)
- Add AI visioning systems before materials enter balers for quality control
- Add unders recovery system (S21-S24 only)

NEW CRF LINE

- Add a new CRF line with new build-out in the Metro area
- Could be stand-alone or added to an existing MRF

Note: upgrades are modeling concepts for a theoretical future system, not projections or calculations for actual individual MRFs.

MRF Types and Future System

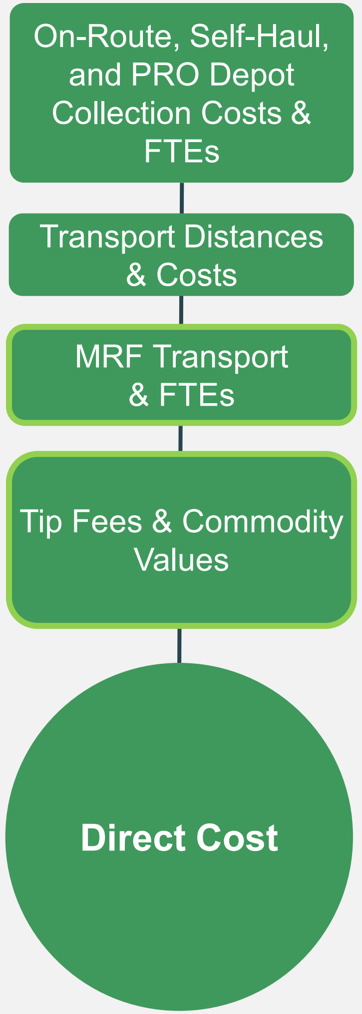
This section describes the number of MRFs included in the modeling, the general types of upgrades added to each MRF, and the concept for a CRF line somewhere in the Metro region.

The costs for the CRF line include all new equipment and infrastructure in the MRF capital tab of the COST module. Facility costs (such as lease and utilities) are in the MRF operations tab. Cost does not include siting, permitting, or land for a new facility.

MRFs	Future Concepts
1 MRF in Salem **3 MRFs A in Metro area**	**Sorts fiber and metal. Transfer all plastic/cartons to new CRF line.** • Upgrade fiber and metal lines (screens, opticals, robot) • Add Quality AI Vision system to each baler
1 MRF B in Metro Area **1 MRF C in Metro area**	**Sorts fiber, metal, and PET. Transfers other plastic/cartons to new CRF line.** • Continues using existing robots/opticals • Further upgrades fiber lines (screens, opticals) • Upgrade metal with container robot for aluminum • Upgrade MRF C to sort thermoform • Add Quality AI Vision system to each baler
2 MRF in Eugene	**No upgrades** • Continues to skim OCC and transfer everything else to Metro area
New CRF line somewhere in Metro area	**Sorts transferred containers.** • New infrastructure (conveyors, scale, baler, rolling stock) • New equipment (robots, opticals, magnets, eddy current) • Add Quality AI Vision system to each baler

NOTE
In S21-S24, all MRFs except the ones in Eugene also receive an unders recovery system to capture small (undersized) materials that would otherwise be disposed of as residuals.

Direct Cost Module



SORTATION COST DATA SOURCES

All MRF cost, equipment, efficiency, and staffing estimates were developed based on:
- Publicly available information
- Confidential discussions with MRF operators in Oregon
- Confidential data from MRFs outside Oregon
- Confidential data from LeadPoint (staffing agency)
- Consultant expertise from past MRF cost of service studies

COMMODITY VALUES

Commodity values were developed using professional judgement and publicly available data sources:

Prices were originally developed in 2020 based on:
- Long-term prices in "Oregon Recycling Market Prices, Cycles, and Trends" prepared by Dr. Jeffrey Morris for Oregon DEQ (https://srmginc.com/images/Recycling-Prices-Analysis.pdf)
- Input from MORE Recycling (now Stina, Inc.) regarding plastics
- Charts of historical commodity prices in Puget Sound compiled by Dr. Jeffrey Morris (https://srmginc.com/northwest-price-histories)
- Commodity prices listed in Resource Recycling magazine articles and market analyses from 2017-2020 (online and print)
- Annual average commodity prices reported by Ontario's Continuous Improvement Fund, used only for commodities without other price data points (https://thecif.ca/wp-content/uploads/2020/05/April-2020-Price-Sheet.pdf)

In 2022, prices were reviewed and adjusted against recent prices on RecyclingMarkets.net for the Pacific Northwest.

DISPOSAL TIP FEES

Publicly available tip fee information from transfer stations and landfills around Oregon.

MRF Capital Equipment Unit Costs

Equipment Type	Unit Cost
Container Infeed & Presort	$ 627,600
New CRF Line with Conveyors, Scale, Baler, Rolling Stock	$ 3,178,000
Wrap-resistant Screens for Paper	$ 527,700
Metal Magnets	$ 75,000
Eddy Current Separator	$ 90,000
Robot Residue, Coated Paper, or Containers	$ 407,600
Optical for Containers	$ 869,000
Optical for Paper	$ 1,400,000
EPS Densifier	$ 25,000
Quality AI Vision System	$ 106,000
Bunkers	$ 158,900
Unders Recovery System*	$650,000

This tab presents the capital costs for new MRF equipment. Costs are depreciated over 10 years to estimate the annual cost.

NOTE
Costs include installation into MRFs.

* An unders recovery system is addition MRF equipment designed to capture and sort undersized recoverable materials that would otherwise be lost to residuals. Materials include shredded and small paper, small metal and plastic items, and flat metal and plastic containers.

Sortation costs also include

Labor: hourly rates, number of workers, & shifts, adjusted in scenarios as new technology reduces manual sorting and increases maintenance requirements

Operations: per-ton costs for operations, maintenance, fuel and utilities, and facility

Transfer costs: per-ton costs for transport applied to tons transferred to the CRF for additional sorting

Residuals costs: per-ton costs for transport and disposal applied to tons of residuals.

Margin: profit margin

Commodity values: range of commodity prices from publicly available sources, such as RecyclingMarkets.net, Resource Recycling, and historical sources

Summary Reporting

Direct Cost and Tonnage Model Outputs

A sixth module, REPORT, summarizes and presents the tonnage and direct cost modeling. It is a self-contained Excel file that compiles outputs from the five calculation modules. Separate tabs allow users to explore and compare scenario outputs.

SUMMARY 1

All scenarios, statewide

- Summary recycling tons, commingled contamination rates, and on-route customer counts
- Total tons marketed, by bale or commodity (including contamination)
- Bale contamination rates from USCL and mixed PRO depot plastics
- Total tons properly marketed, by material type
- Summary of direct costs (with sensitivity analysis) and FTEs

SUMMARY 2

Select up to seven scenarios compare side-by-side

- Statewide tons properly marketed, by material type
- Sortation capture rate for materials collected in the USCL

COLLECTION REPORT

Select up to five views to compare side-by-side (chose scenario, statewide or specific grouping, all sectors or specific sector).

- Tonnages by material generated and collected for recycling, direct disposal, or organics

DIRECT COST REPORT

Select up to five views to compare side-by-side (chose scenario and statewide or specific grouping)

- Detailed recycling and garbage system direct costs, with sensitivity analysis
- Detailed FTEs

PROCESSING REPORT

Select up to seven scenarios to compare side-by-side

- Generation: tons generated, by material
- Collection: tons collected as garbage, organics, or recycling (by material)
- Sortation: tons entering sortation facilities from USCL or PRO mixed plastics, tons properly sorted, and MRF capture rate (by material)
- Final disposition: tons disposed (garbage, MRF residue, bale contamination), recycling tons properly marketed, tons of recovered organics, and system-wide capture rate after sortation.

State of Oregon Department of Environmental Quality

OVERVIEW OF SCENARIO MODELING

Oregon Plastic Pollution and Recycling Modernization Act

Cascadia Consulting Group | Bell & Associates | Circular Matters

APPENDIX C. Calculating indirect and net costs

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March 14, 2023

Appendix C. Calculating Indirect and Net Costs

COMPONENTS OF NET COST

This report characterizes waste management scenarios in terms of "net" or "total" costs, which are calculated from three major components:

- Direct costs;
- Revenues from commodity sales; and
- Indirect costs.

The net or total cost is equal to direct costs, minus revenues from commodity sales, plus indirect costs.

Direct costs and revenues will be familiar concepts to most readers. Direct costs are money outlaid to operate the (in-scope) waste management system, for example the costs of fuel for collection trucks or salaries for collection staff. Revenues are moneys received from selling (in-scope) recyclable materials to buyers of those materials. Both are recorded in dollars.

Indirect costs will be less familiar to many readers. They express effects of the waste management system that are less directly perceptible, but just as real.

THE CONCEPT OF INDIRECT COSTS

Oregon's waste management system, like any system operating in the real world, has environmental and human consequences that are not reflected in traditional accounting statistics such as direct costs and revenues. For example, operating a diesel-powered recycling collection truck leads to several types of environmental impacts, including:

- Emissions of respiratory pollutants often known as "PM 2.5," elevated levels of which have been associated with increased asthma attacks, hospital visits, and reduced ability to work.
- Emissions of greenhouse gases, which contribute to climate change, with consequences that stretch over the entire world, including loss of agricultural land, need for new infrastructure, and higher prices for raw materials.

Such impacts are often expressed in technical terms, such as tons of pollutant. But these impacts have very real financial consequences for both individuals and societies. For example, individuals (or their insurance companies) have to pay for hospital visits; governments (or their taxpayers) have to pay for new infrastructure.

A calculation of "indirect costs" for a system is the sum of all the financial costs that can reasonably be connected with the system's environmental impacts. Indirect costs are expressed in dollars and can thereby be compared to or combined with more traditional accounting statistics such as direct costs or revenues.

It is important to note that indirect costs need not represent a harm to society; indirect costs may be negative and represent a benefit to society. While the recycling truck in the example above is emitting pollutants, the recycling it is enabling may prevent the need for manufacturing based on "virgin" raw materials from mines and forests. Since creating products with recycled feedstocks usually creates less pollution than creating products from "virgin" feedstocks, recycling represents a net reduction in pollutants – and can be associated, through the concept of indirect costs, with a financial benefit or savings to society. The benefit of the recycling activity would be offset somewhat by the cost or harm associated with operating the truck.

OVERVIEW OF DEQ'S CALCULATION OF INDIRECT COSTS

In the present analysis, Oregon DEQ has calculated an indirect cost for each of the several dozen waste management scenarios under consideration. Because each waste management scenario is defined by its particular combination of materials, "dispositions" (e.g., recycling vs. landfilling) and transportation characteristics, this was a complex endeavor. The overview below will be followed by a detailed treatment of methods.

The calculation started when Cascadia Consulting delivered its waste management scenarios to DEQ, as a comprehensive database of materials, dispositions, and transportation characteristics.

These weight, disposition, and transportation data served as input to DEQ's Waste Impact Calculator (WIC) model. WIC is an open-source, independently reviewed life cycle model about solid waste. Documentation and downloads are available at https://or-dept-environmental-quality.github.io/wic/.

DEQ's calculation of indirect costs

Waste management scenarios
characterized as tons, dispositions, distances

↓

Waste Impact Calculator Model

↓

Waste management scenarios
characterized as 13 separate environmental impacts

↓

Damage cost factors for 13 different environmental impacts

↓

Waste management scenarios
characterized as dollars of indirect costs

DEQ used WIC to calculate thirteen different environmental impacts for each of Cascadia's waste management scenarios: global warming, human toxicity (cancerous), eutrophication, acidification, ozone depletion, natural land transformation, smog air, ecotoxicity, metal depletion, fossil depletion, water depletion, human health (particulate air), and human health (non-cancerous).

Those environmental impacts were in turn converted to indirect costs by the application of "damage factors" drawn from the economics literature. Damage factors express the financial cost (or benefit) associated with increases or decreases in environmental impact. DEQ used midpoint values of the damage factors found in two sources:

- For global warming, human toxicity (cancerous), eutrophication, acidification, ozone depletion, smog air, ecotoxicity, human health (particulate air), and human health (non-cancerous): *Morris, Jeffrey. 2020. Economic Damage Costs for Nine Human Health and Environmental Impacts* (https://srmginc.com/images/Final-DEQ-Metro-Report.pdf).
- For natural land transformation, metal depletion, fossil depletion, and water depletion: S&P Global TruCost, as part of the GaBi life cycle analysis system (https://sphera.com).

These sources were chosen because of their credibility and compatibility with DEQ's previous work. The Morris (2020) paper was the result of an extensive review of the literature combined with a statistical harmonization and was used in earlier DEQ work that informed the Recycling Modernization Act. The TruCost data is incorporated into GaBi, the life cycle analysis system that underlies the impact characteristics used by WIC.

After this transformation, each of Cascadia's several dozen waste management scenarios was characterized by an indirect cost expressed in dollars – the same units used for estimates of direct costs and revenues. This allowed the calculation of net system costs.

DETAILS OF DEQ'S NET AND INDIRECT COST CALCULATIONS

For each waste management scenario (S00, S01, etc) described by Cascadia Consulting, Oregon DEQ calculated the "net cost" or "total cost" as:

$$C = T + S - R$$

where

C is net or total cost,

T is direct cost,

S is indirect cost, and

R is revenues.

R and T were taken directly from Cascadia's economic projections. Cascadia provided a single midpoint R value for each scenario. Cascadia provided T in more detail, giving midpoint estimates for costs in eight subcategories T_h. Total T was the sum of those subcategory midpoints:

$$T = \sum T_h$$

The subcategories were “recycling engagement,” “recycling collection,” “recycling consolidation and transfer,” “recycling sortation,” “disposal administration,” “disposal collection,” “disposal consolidation and transfer,” and “disposal tip fees.”

Meanwhile, S had a considerably different provenance. S was the result of a detailed calculation in which DEQ estimated the environmental impacts of the waste management activities described in Cascadia’s scenarios, and then estimated the “indirect” or “social” costs associated with those impacts.

Cascadia’s models contributed to S by providing the details of waste management activities in each scenario, in particular the names of waste materials managed (e.g., steel, cardboard, glass), the end-of-life “dispositions” to which those materials are directed (e.g., landfilling, recycling, etc.), the weights of each material assigned to each disposition, and transportation characteristics related to collecting materials and delivering them to their end-of-life dispositions.

DEQ took these waste management data and further transformed them. As mentioned earlier, waste management quantities and activities were translated into environmental impacts using the WIC model, and environmental impacts were translated into indirect costs using damage cost factors from Morris (2020) and TruCost.

Note that WIC’s impact factors often associate recycling activities with negative impact values, representing "credits" or reductions in emissions. The origin of these credits is the presumption that recycled feedstock prevents production using higher-impact virgin feedstock. So even though recycling processes themselves create environmental impacts (for example, MRF operations consume electricity), the net effect is to lower impacts. Negative impact values in turn lead to negative values for indirect costs.

A more complete explication of the calculation of indirect costs begins with the recognition that all solid waste materials take part in the “materials life cycle.” This phrase recognizes the reality that all materials have been, or will be, produced (extracted from the earth and transformed into useful products), used, and given some end-of-life treatment (e.g. landfilled, recycled, etc).

DEQ’s calculation of indirect costs focused on the “end-of-life” phase of the life cycle. Though the environmental impacts and indirect costs associated with the production and use phases (prior to discards) are likely quite large, they could be ignored for the purposes of this study. DEQ’s primary analytical goal here was to compare recycling scenarios and describe their differences. Meanwhile, all of Cascadia’s scenarios were equivalent in terms of waste generated, so the environmental impacts and indirect costs associated with production and use of materials would also be identical for each scenario. Stated another way, none of the waste management scenarios considered changing the amount or type of waste generated; scenarios only differed in the ways waste was handled.

The end-of-life impacts *(I)* for each scenario, in each of the thirteen impact categories *i*, were estimated for three detailed sub-phases: end-of-life processing, end-of-life transport, and additional "depot" transport. More formally:

$I_{EOL,i}$ = impact of the end-of-life waste management process (e.g. landfilling, incineration, or recycling) in impact category *i*

$I_{EOLT,i}$ = impact of transportation from collection site to processing site (e.g. incinerator, landfill, or MRF), in impact category *i*

$I_{DEPOT,i}$= additional impact associated with transport from homes or businesses to recycling depots in impact category *i* (only applied when the management scenario involved PRO recycling depots).

$I_{EOL,i}$ and $I_{EOLT,i}$ were each the result of functions involving waste material classification (e.g. aluminum, steel, glass), end-of-life disposition process (e.g. landfilling, incineration, recycling) and transportation from home or business to processing site. For every relevant combination of waste material j and end-of-life disposition k, and for thirteen impact categories i,

$$I_{EOL,i} = \sum W_{j,k,} Q_{j,k,i}$$

$$I_{EOLT,i} = \sum \frac{m_{j,k}}{m_0} W_{j,k} U_{j,k,i}$$

where

$W_{j,k}$ is the weight of material j applied to end-of-life process k

$Q_{j,k,i}$ is the WIC impact factor, converting weight to impact, for material j and process k, for impact category i

$U_{j,k,i}$ is the WIC impact factor, converting weight to impact, for transporting material j to a site for process k, for impact category i, given a distance m_0

m_0 is the default end-of-life transport distance, in miles, that the WIC model associates with material j and process k

$m_{j,k}$ is the reported end-of-life transport distance, in miles, provided by Cascadia for material j and process k, between collection point (e.g. home, business) and processing point (e.g. landfill, MRF).

$I_{DEPOT,i}$ was only calculated for scenarios involving PRO depot collection facilities. $I_{DEPOT,i}$ was the product of a multiplication of a distance traveled and a special impact factor:

$$I_{DEPOT,i} = m_{DEPOT} Q_{DEPOT,i}$$

where

m_{DEPOT} is the total "additional" private car miles driven, across all materials in the entire scenario, in order to deliver recyclable materials to depots. For more information regarding the derivation of this value for different scenarios, please see Appendix B.

$Q_{DEPOT,i}$ is a factor, created by DEQ life cycle analysis staff, expressing environmental impact per private car mile driven for impact category i.

Environmental impacts $I_{EOL,i}$, $I_{EOLT,i}$, and $I_{DEPOT,i}$ were converted to indirect costs $S_{EOL,i}$, $S_{EOLT,i}$, and $S_{DEPOT,i}$ through the application of a "damage cost factor":

$$S_{EOL,i} = I_{EOL,i} F_i$$

$$S_{EOLT,i} = I_{EOL,i} F_i$$

$$S_{DEPOT,i} = I_{EOL,i} F_i$$

where

$S_{EOL,i}$ = indirect cost of the end-of-life waste management process (e.g. landfilling, incineration, or recycling) for impact category i

$S_{EOLT,i}$ = indirect cost of transportation from collection site to processing site (e.g. incinerator, landfill, or MRF) for impact category i

$S_{DEPOT,i}$ = additional indirect cost of transportation from homes or businesses to recycling depots for impact category i (only applied when the management scenario involved recycling depots).

F_i = "damage cost factor" expressing indirect costs per unit of environmental impact, drawn from the midpoint of the range given by Morris (2020, "Economic Damage Costs for Nine Human Health and Environmental Impacts") and TruCost (incorporated in GaBi life cycle assessment software, Thinkstep, Inc.), and corrected to output 2021 dollars.

The last step in calculating S was summing indirect costs across all three life cycle subphases and all thirteen impact categories:

$$S_i = S_{EOL,i} + S_{EOLT,i} + S_{DEPOT,i}$$

where S_i = the total indirect cost associated with impact category i. These figures were then summed to quantify total S:

$$S = \sum S_i$$

Since the units of S are dollars, S can be combined with T and R to reflect net cost:

$$C = T + S - R$$

ASSESSMENT OF UNCERTAINTY AND ITS IMPLICATIONS

This report generally portrays values for C, T, R, and S as single numbers, for brevity and clarity of comparison among scenarios. However, there is uncertainty associated with those numbers. Neither DEQ nor Cascadia can be expected to precisely foretell the exact values of financial or environmental statistics years in the future. Rather, single values of C, T, S, and R reported for each scenario should be viewed as the central points from a well-reasoned range of likely future conditions.

In the fall and winter of 2022, DEQ conducted a robust and detailed investigation into the effects of uncertainty on computed values of C, T, S, and R. This Monte Carlo-style analysis restated the net cost formula

$$C = T + S - R$$

as a generalized function,

$$C = f(\boldsymbol{T_h}) + f\left(W_{j,k}, \boldsymbol{Q_{j,k,i}}, m_{j,k}, m_0, \boldsymbol{U_{j,k,i}}, m_{DEPOT}, Q_{DEPOT,i}, \boldsymbol{F_i}\right) - \boldsymbol{R}$$

and allowed the factors in bold ($\boldsymbol{T_h}$, $\boldsymbol{Q_{j,k,i}}$, $\boldsymbol{U_{j,k,i}}$, $\boldsymbol{F_i}$, and $\boldsymbol{R}$) to randomly range within confidence limits provided by the authors of the relevant data. For example, the confidence limits for R (revenues) were provided by Cascadia Consulting, who also provide the single-point values of R used in the main analysis. For each scenario, 10000 random variates of each factor were created. Variates for each factor were then recombined at random and used to produce 5000+ sets of T, S, and R, from which 5000+ values of C could be calculated. These 5000+ values were then summarized statistically, yielding mean and standard deviation values for T, S, R, and C for each scenario. These allowed the creation of new confidence limits for C, limits that reflect the wide range of possibilities in values for all the factors contributing to C.

This exercise provided DEQ with two significant findings.

- **Uncertainty is less relevant in comparative analyses.** Projected future mean values of C, S, and R for each scenario did have broad confidence limits, with coefficients of variation often >20%. However, projecting future values was not the main goal of the analysis. Rather, DEQ aimed to *compare* the performance of waste management scenarios against each other. In comparative analyses, uncertainty in factors like $F_{i=4}$ (the damage cost factor for acidification) is irrelevant, because even though DEQ does not know the exact future value of $F_{i=4}$, the future $F_{i=4}$ will be the same for all scenarios. (Stated another way, nothing about the scenarios imagined today will affect the damage cost factor for acidification in the future.) When this type of equivalence is recognized in the calculation of S, the coefficients of variation associated with mean values of C drop to around 4%. Most of this remaining variation arises from uncertainty in future R (revenues).

- **Net costs are very similar for most scenarios.** Mean values of C for nearly all scenarios fall within a fairly small range around $490-520 million per year. Most pairs of scenarios do not statistically differ from each other in terms of net system costs.

It is important to put the second conclusion in context. The law (ORS 459A.914) requires that the Environmental Quality Commission consider a large number of factors while choosing materials and methods related to the statewide collection list, including:

(a) The stability, maturity, accessibility and viability of responsible end markets; (b) Environmental health and safety considerations; (c) The anticipated yield loss for the material during the recycling process; (d) The material's compatibility with existing recycling infrastructure; (e) The amount of the material available; (f) The practicalities of sorting and storing the material; (g) Contamination; (h) The ability for waste generators to easily identify and properly prepare the material; (i) Economic factors; (j) Environmental factors from a life cycle perspective; and (k) The policy expressed in ORS 459.015 (2)(a) to (c).

The calculation of indirect and net costs clearly does not reflect all those considerations. The present analysis is an extensive consideration of element *(i)*, economic factors, and incorporates a partial consideration of element *(j)*, environmental factors from a life cycle perspective. Anticipated yield loss (element *(c)*) is incorporated into Cascadia's flows of material modeling and direct cost (yield loss at a MRF requires transport and disposal), while the underlying life cycle impact factors in WIC also incorporate industry-average assumptions involving yield loss in primary material industries that use recycled wastes. Factors *(a)*, *(b)*, *(d)*, *(e)*, *(f)*, *(g)*, *(h)*, some aspects of *(j)*, and *(k)* remain. If economic factors do not differ notably between scenarios, it may free the Environmental Quality Commission and its agents, when constructing policy, to give more weight to all the other considerations mentioned by the law.