

Appendix A
Single vs. Dual Stream Annotated Bibliography

An Assessment of Dual and Single Stream Recycling. Niagara Region, 26 Mar. 2013,
www.cascadiaconsulting.com/uploads/pdf/rr-ss4_processing_mar_2008.pdf.

This 2013 report from the Niagara region of Canada mostly summarizes the Waste Diversion Ontario's 2013 study, "An Assessment of Single and Dual Stream Recycling" (which is also covered in this bibliography) while also providing justification for Niagara's use of a dual stream system, as the cost per household was on average twelve dollars lower when using dual stream and residue rates were about eight percent lower. The report is not especially detailed, but there are some statistics about how it is more cost-effective for the Niagara region to use a dual stream system than a single stream one. Additionally, the report provides a quick and useful summary of a much more technical and detailed study.

An Assessment of Single and Dual Stream Recycling. 2013,
https://thecif.ca/projects/documents/716-Final_Report-REV.pdf

This 2013 report assesses the efficiency and cost effectiveness of dual and single stream recycling based on general research and case studies with data culled from current program performance in several large Ontario municipalities. The report begins by laying out data which lists a number of factors in determining the costs of single stream and dual stream recycling, such as choice of collection container, labor costs, etc. and notes that many of the savings from single stream are from the automation it enables, not the commingling of materials. The report then features several statistics and case studies about processing dual stream recycling, end markets, program participation, and diversion rates in bulleted list format. The report then move on to case studies, which are fairly evenly split between single and dual stream systems and show no clear preference for one over the other. One common thread between all the case studies is that the report emphasizes that recycling systems must function locally, and cites MRF processing capacity and population density of the area in question as key factors. Finally, the report directly compares single and dual stream systems with data from the largest municipalities using each system. While single stream programs recovered and marketed more material, the dual stream programs received a fourteen percent higher price per ton of material sold. Additionally, there was little difference in collection costs between dual and single stream programs, despite dual stream programs often being located in areas with lower population density than their single stream counterparts. In terms of processing costs, single stream programs had a processing cost around fifteen percent higher than dual stream programs, and net system costs per household were thirty two percent lower for dual stream systems. The report also compares rates of material recovery between the two systems, finding that dual stream systems recovered more aluminum and steel, two high price recyclable commodities. To conclude, the report states that neither single or dual stream is definitively superior and offers suggestions for further research, such as the effects of pay-as-you-throw policies and other garbage disincentives on recycling rates. Generally, the report is rich in statistics, charts, and other data useful for gaining a better understanding of the composition of recycling streams as well as the prices these recyclables fetch as part of dual and single stream systems.

Daniels, Jeff. “Why Recycling Business Is Feeling so Discarded These Days.” *CNBC*, CNBC, 9 Mar. 2016,

www.cnbc.com/2016/03/09/why-recycling-business-is-feeling-so-discarded-these-days.html.

This article briefly describes the decrease in profitability of recycling businesses due to low commodity prices driven by a loss of markets for low quality materials. This has been especially problematic for single stream recycling considering it is of lower quality and fetches lower prices per ton than its dual stream counterpart. However, the article goes on to say that major solid waste companies will likely renegotiate contracts in the future, charging more per ton of recycling in order to recoup losses.

“Kerbside Recycling: Indicative Costs and Performance .” *The Waste and Resources Action Programme*, June 2008,

www.wrap.org.uk/sites/files/wrap/Kerbside%20collection%20report%20160608.pdf.

This UK report tests and details best practices for curbside recycling, splitting its report into sections on single stream and dual stream systems. The report is helpful in assigning statistics for each collection type to both rural and urban areas. Furthermore, the report discusses net costs for recycling per household, based on dual or single stream, urban or rural, the collection vehicle type, and collection frequency. Generally, the report offers a view of the variety of factors that contribute to the cost of recycling and ways these costs can be minimized.

Kinselaa, Susan, and Richard Gertman. *Processing: The Lynchpin of Recycling Success*.

Resource Recycling, Mar. 2008,

www.cascadiaconsulting.com/uploads/pdf/rr-ss4_processing_mar_2008.pdf.

This article examines how single stream has reduced the possibilities for recycled products options due to commingling and low quality materials. The article then offers suggestions for designing or retrofitting processing facilities to accommodate the local recycling programs they serve. The article describes the three most common types of residue found at MRFs; contaminants, process residue, and market residue and speaks briefly about best practices for collecting commercial recycling. Generally, the article offers a brief overview of some of the factors that should be considered when operating a MRF to better meet end market demands.

Laskow, Sarah. “Single-Stream Recycling Is Easier for Consumers, but Is It Better?” *The Atlantic*, Atlantic Media Company, 19 Sept. 2014,

www.theatlantic.com/technology/archive/2014/09/single-stream-recycling-is-easier-for-consumers-but-is-it-better/38036

This *Atlantic* article is a quick read on how single stream passes along the cost of processing to MRFs and how single stream's initial recycling rate is not reflective of its actual recycling rate, which is much lower due to residuals.

Morawksi, Clarissa. "Single-Stream Uncovered." *Resource Recycling*, Feb. 2010,

www.container-recycling.org/assets/pdfs/media/2010-2-SingleStreamUncovered.pdf.

This article summarizes the findings of a report funded by the Container Recycling Institute on the economic and environmental impacts of single stream recycling. The report, "Understanding economic and environmental impacts of single-stream collection systems" is also covered in this bibliography. The article explains that often the switch from dual stream to single stream was initiated by a desire for higher recycling rates (in some cases, these were needed to meet legislated targets) in a cost-efficient manner. The use of large roll carts and single compartment trucks kept labor and transportation costs low. However, single stream presents an economic challenge for paper manufacturers and others who utilize recycled materials in their businesses. The cost of sorting commingled materials and removing contaminated materials has proved to be a large economic burden for paper mills, plastic processors, aluminum recyclers, and others. The article also explains that glass is the material most negatively affected in terms of the disparity of recoverable materials between single stream and dual stream, as it is impossible to prevent glass from shattering during single stream collection and processing. However, the article proposes separating breakables from fiber before they are broken at the MRF as a potential remedy to this issue. To do this, the materials could be separated at the MRF on rubber conveyor belts before being broken. Generally, the article emphasized the importance of salvaging clean, high quality materials without taking an explicit stance on the dual vs. single stream debate.

Paben, Jared. "Experts duel over dual-stream's merits." *Resource Recycling*, 14 May 2019,

<https://resource-recycling.com/recycling/2019/05/14/experts-duel-over-dual-streams-merits/>

This article discusses how Milpitas, a city in northern California, which made the switch to dual stream recycling with automatic collection in 2017. The switch has been a source of financial benefit thanks to an average price of 94 dollars per ton of recycling sold and a cost avoidance of 80 dollars per ton of landfill transport and tipping fees. Dual stream collection costs 21 cents per household per month and has the potential benefit of 68 cents per household thanks to revenue from recyclables sold, yielding a net benefit of 47 cents per household per month. The article goes on to detail the importance of a well managed public information campaign when switching to dual stream to lower contamination rates and insure citizen cooperation in the program.

Recycling: Cost Benefit Analysis. Apr. 2007,

www.mfe.govt.nz/sites/default/files/recycling-cost-benefit-analysis-apr07.pdf.

This New Zealand report presents a cost-benefit analysis for recycling, with results separated by material type. Benefits of recycling were calculated by adding savings in landfill costs (calculated by combining the cost of landfilling and the environmental impacts of landfilling), saved disposal collection costs, and consumer preference benefits (the value consumers assign to recycling instead of creating waste). The cost of recycling was calculated by adding up the costs of collection and sorting, then subtracting the value of the recyclables when sold to end markets. The report then further breaks down the assumptions and methodology of their cost-benefit analysis, rendering it a useful document for anyone curious about the methodology of similar analyses or seeking to conduct one themselves. One helpful way this report sheds light on an often left out piece of the benefit of recycling is by laying out the various external costs of landfilling, including atmospheric emissions and leachate. It also discusses the disamenity effects of landfills, explaining hedonic pricing studies of the value of homes not being located near a landfill and the willingness to pay of those whose homes were near a landfill for a reduction in the impacts of the landfill (litter, dust, odor, etc.).¹ Additionally, the report details the environmental effects of specific types of waste being landfilled, providing estimates for their methane emissions rates and quantifying the cost of these emissions using carbon pricing to quantify the benefit of diverting such waste. The report also includes the survey it used for its willingness to pay (direct consumer benefits) survey, which is a useful tool for others hoping to undertake a similar project. Overall, this report is an invaluable resource for understanding the cost-benefit breakdown of recycling and its component parts.

“Single-Stream Recycling.” *Scientific American*, 2018,

www.scientificamerican.com/article/single-stream-recycling/.

This *Scientific American* article discusses how the main benefit of single stream recycling is increased recycling rates (less recyclable material ending up in the garbage). Single stream’s simplicity makes it easy to use and raises recycling rates. However, the article acknowledges that single stream produces more residuals than dual stream and brings up problems with the end markets for single stream recyclables. Single stream has issues with contamination and leads to materials being rejected or used for lower-end applications. Overall, the article expresses skepticism about the supposed economic and environmental advantages of single stream recycling.

Staub, Colin. “Dual-Stream Collection Regains Appeal in Some Areas.” *Resource Recycling News*, Resource Recycling, 17 July 2018,

<https://resource-recycling.com/recycling/2018/07/17/dual-stream-collection-regains-appeal-in-some-areas>

This article examines programs that have recently made the switch from single to dual stream recycling amid China’s National Sword policy and a downturn in the market for recycled materials. One county in Ontario explained their reasoning for the switch as an overly saturated domestic market driving down

¹ Hedonic pricing is a regression technique used to estimate economic values for environmental or other characteristics that affect the market price of a good. It is most frequently used to estimate the value of environmental quality or environmental amenities.

prices and requiring higher quality materials. The county estimates that the new dual stream system will have a net savings effect thanks to lower processing costs, higher revenues from selling recyclables, and less material landfilled. The article examines cases in California and Florida as well. Finally, the article profiles a hauler that chose to make the switch to dual stream for its commercial clients, citing a ripple effect from China's National Sword policy as the primary reason.

Seldman, Neil. "Recycling Activist Louise Mann Calls for Transparency and Accountability Ordinance." *Institute for Local Self-Reliance*, 12 June 2019,

<https://ilsr.org/louise-mann-accountability-ordinance/>.

This article explains the importance of transparency in recycling and why ordinances advocating for recycling transparency are needed to create effective recycling systems.

Seldman, Neil. "The (Small) Private Sector to the Rescue: RoadRunner Recycling, Inc." *Institute for Local Self-Reliance*, 31 May 2017,

<https://ilsr.org/the-small-private-sector-to-the-rescue-roadrunner-recycling-inc/>.

This article is a case study of RoadRunner Recycling, a company that helps small businesses recycle and works to find end markets for their recyclables. RoadRunner company president Graham Rihn believes his business model is only feasible with dual stream recycling.

Toto, DeAnne. "Taking Sides on Single- or Dual-Stream Recycling." *Recycling Today*, Recycling Today, 23 May 2019,

www.recyclingtoday.com/article/wasteexpo-2019-dual-stream-vs-single-stream/.

This article details case studies of exceptional dual stream and single stream collection systems and has brief interviews with officials who chose to switch from single to dual-stream. The article profiles collection systems in Palm Beach, Florida, Lake Worth, Florida, and Milpitas, California. The article also examines the importance of education in reducing contamination and raising recycling rates.

"Understanding Economic and Environmental Impacts of Single-Stream Collection Systems."

Container Recycling Institute, Dec. 2009,

www.container-recycling.org/assets/pdfs/reports/2009-SingleStream.pdf.

"Understanding economic and environmental impacts of single-stream collection systems" is a 2009 report on the impacts of single-stream collection with a specific focus on the material quality and end destinations of materials collected. This report aims to examine single stream not only in terms of the upfront cost to municipalities, counties, etc. in paying for recycling services, but also the economic value and environmental impacts generated by the recycled materials to capture the full picture of single stream. The report emphasizes that closed loop recycling, which is dependent on a regular supply of clean material, yields much higher environmental benefits than downcycling. The report goes on to outline

recommendations for municipalities and states' recycling programs, including conducting an assessment of their current recycling operation and considering more efficient alternatives, such as dual-stream or modified single stream. The report then explains the history of single stream and details how Chinese demand for materials and low labor costs allowed single-stream materials to be sold despite high levels of contamination. However, the economic downturn of 2008 drastically altered the market for low quality materials, coupled with new Chinese standards for material quality. Due to this, many low quality materials from single stream sources have failed to find end markets. Next, the report explains single stream collection costs, as well as the upfront costs required to begin single stream recycling. The report then discusses how single stream raises processing costs and creates inefficiencies largely due to contamination. Another problem is recyclables ending up in the wrong separated stream, where they are often sent directly to disposal. The report goes on to address the question of yield, explaining that although single stream takes in a greater percentage of recyclables, dual stream has a greater percentage of output when it comes to materials actually recycled. The report then details the higher recovery levels produced by dual or multi-stream in three key materials; aluminum, glass, and plastic. To conclude, the report explains how recycling has by and large become a system focused on collecting the maximum amount of material at the lowest cost possible. The report argues that instead recycling should aim to foster a closed loop system through ensuring recyclables are of high quality to avoid upstream pollution and greenhouse gas emissions from production with virgin materials. Overall, the report is incredibly valuable as it provides data from a variety of sources about the costs and efficiency rates of dual stream recycling.