CIF # 821.3.2

Glass Clean-up System
Niagara Region

Final Project Report, April 2016

Niagara Region

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Niagara Region
PUBLIC WORKS

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Acknowledgement:

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1 Overview

This is the final report of Project CIF # 821.3.2: Niagara Region Glass Clean-up System, implemented by *Niagara Region* (the Region) over 2014 and 2015.

The purpose of this project was to address the Region's issues with processing mixed broken glass (MBG) within its EcoGlass program. The EcoGlass program recycles glass into fine particles that are used for abrasives (e.g., sandblasting). The Region owns the Material Recovery Facility (MRF) and contracts Niagara Recycling (NR) to manage all MRF operations, including the operations of the EcoGlass plant. The EcoGlass processing system experienced issues with the Region's MBG feedstock, after a glass breaker screen and other upgrades were completed in Spring 2010, which forced the Region to ship its MBG to a third party for pre-processing or purchase cleaned glass to use in the EcoGlass process. To overcome this issue, the Region wished to investigate an in-house method to process its MBG that would produce an acceptable end product.

The scope of this project, therefore, included:

- Upgrading the MRF's glass processing equipment through the purchase and installation of a Glass Cleaning System (GCS); and
- Evaluating the new GCS's performance.

The Region applied to the CIF in April 2013 for funding to purchase and install a GCS in its MRF to increase operation efficiencies and to produce higher revenues from curbside collected MBG. Specifically, the GCS will enable the Region to avoid costly disposal costs for MBG to other facilities and permit the processing of the Region's MBG through the Ecoglass manufacturing facility. As well, the GCS may provide the Region with an opportunity to process MBG from other municipalities with the purpose of cleaning their glass to current market specifications. The GCS was installed and commissioned in April 2014.

Prior to the installation of this system, the Region was shipping its MBG to a third party facility at a cost of $28 to $30 per tonne; however, due to the interruption in demand by the glass markets, the Region began stockpiling its MRF MBG at its Fort Erie landfill site. In 2013, the Region procured the GCS and in April 2014, the system was successfully installed and commissioned. Since the GCS's installation, the Region has stopped stockpiling its MRF MBG and begun processing it through the GCS, which has an operational capacity of approximately 3 to 5 tonnes per hour depending on the amount of MBG contamination and moisture levels.

The GCS installation has been beneficial for the Region, as it has allowed it to use its curbside collected MBG feedstock in the production of EcoGlass, thereby avoiding costs associated with stockpiling its MBG or importing clean glass for the EcoGlass process. The GCS system recovered approximately 60% of the MBG feedstock and the estimated payback period for the $252,607 investment was approximately 17 months. Once the Region depletes its current MBG stockpile, it will also have the capacity to process MBG from other jurisdictions, thereby adding a new revenue stream to its recycling program.

A GCS may be suitable for municipalities who are currently disposing of their MBG or wishing to provide a more marketable MBG product for the recycled glass marketplace. Factors that may influence the economic feasibility of a GCS for a municipality include their existing processing and disposal costs of MBG, potential for increased revenue from the recycled glass marketplace for a cleaner MBG product, and potential increased processing efficiencies.

2 Project Monitoring and Evaluation

The GCS project included a monitoring and evaluation component to assess the performance of the GCS and its cost-effectiveness. The key metrics used for monitoring and evaluation included:

- Composition of MBG feedstock processed;
- Tonnes of the Region's MBG feedstock processed and average processing rate;
- Tonnes of residue produced while processing MBG;
- Operational issues / downtime while processing MBG; and
- Costs incurred and avoided using the GCS to process the Region's MBG feedstock;

The results of the GCS's performance and financial implications are provided in Sections 3 and 4.

3 Review of GCS Performance

The new GCS funded through the CIF is comprised of three main system components:

- A trommel screen;
- A bucket elevator; and
- An aspirator.

The EcoGlass process includes eight steps to remove residue from the glass stream; the trommel and aspirator are two of these steps and, along with the bucket elevator, are the focus of this evaluation. This section reviews the performance of these three items and includes discussion on:

- Feedstock composition;
- System throughput and processing yields; and
- Performance and initial operational Issues.

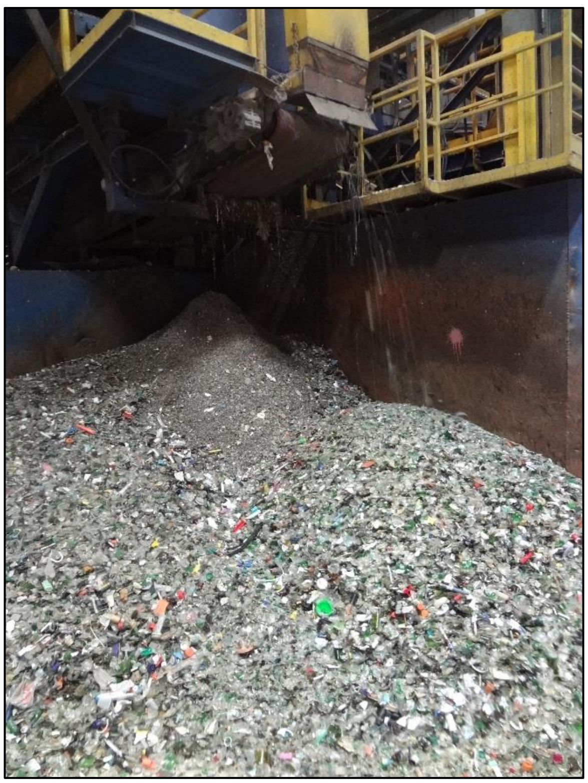
3.1 Feedstock Composition

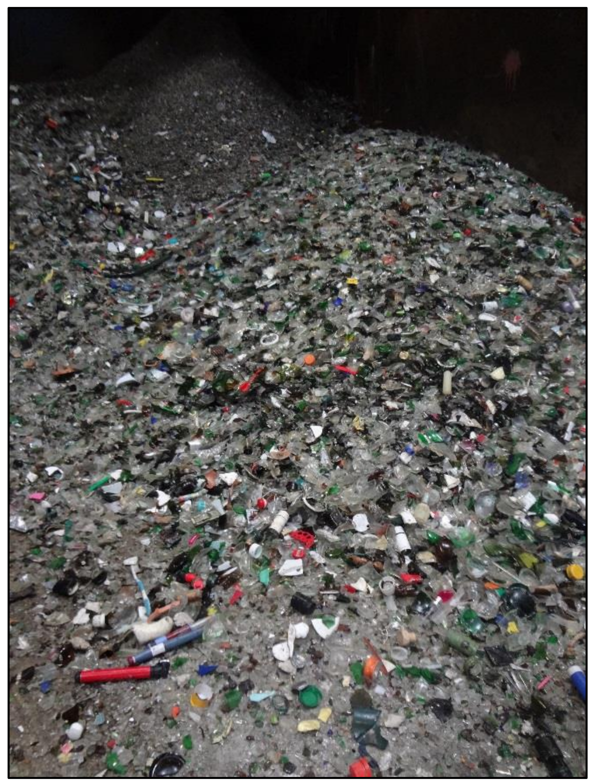
The feedstock composition of MRF MBG was audited seven times over a 12-month period. The total weight of feedstock sampled was 251 kg, with sample sizes between 22 kg to 68 kg. The sampled feedstock consisted of 85.9% glass (79.0% was glass >1/4” in diameter and 6.9% was glass <1/4” in diameter) and 14.1% was other material. Table 1 presents the composition of the glass feedstock samples. Figure 1 depicts an example of the feedstock pile at the Niagara MRF.

Table 1: Feedstock Composition Audit Results

Feedstock Sample Composition (Percentage)	October 15, 2014	January 9, 2015	April 10, 2015	July 9, 2015	July 27, 2015	August 6, 2015	October 8, 2015	Weighted Average
Glass Size >1/4"	80.1%	78.5%	66.0%	83.8%	78.8%	80.8%	79.2%	**79.0%**
Glass Size <1/4"	7.9%	4.2%	7.2%	4.8%	9.1%	12.1%	6.2%	**6.9%**
Plastic	5.3%	7.5%	5.2%	4.2%	3.0%	1.0%	3.1%	**4.7%**
Metal	1.0%	1.4%	2.1%	2.4%	4.0%	2.0%	2.3%	**1.9%**
Aluminum Cans	0.3%	0.9%	0.0%	0.6%	0.0%	0.0%	0.0%	**0.4%**
Residue	5.0%	7.5%	19.6%	3.6%	4.0%	3.0%	6.9%	**6.5%**
Unsortable Material	0.3%	0.0%	0.0%	0.6%	1.0%	1.0%	2.3%	**0.6%**
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
Sample Size (kg)	68	49	22	38	22	22	29	**251**

Figure 1: Example of MRF MBG Feedstock





The data from the feedstock audits can be used to prepare a material specification to be used by other MRF's that are interested in shipping their MBG to the Region's MRF (once the Region's MBG stockpile is used up and the MBG processing system has available capacity). The specification that is based on the audit data, is provided in Table 2.

Table 2: Potential Future MBG Specifications

Material	Specification
Glass size: >1/4"	75%
Glass size: < ¼"	10%
Plastic:	Up to 5%
Ferrous Metal:	Up to 10%
Aluminum:	Up to 1%
Organic (paper, food):	Up to 2%
Residue (non-organics)	Up to 4%

3.2 System Throughput and Processing Yields

Over 2014 and 2015, the new GCS processed 7,845 tonnes of MBG, achieving an average yield of 59%. In 2015, the average processing rate for the EcoGlass manufacturing facility was 3.48 tonnes per hour; however, the design capacity of the GCS component of this is much higher and is limited only by the throughput capacity of other facility components (particularly, the dryer). The throughput capacity changes according to season. Moisture content is the greatest challenge faced by the GCS, and as a result production is reduced through the winter months. Peak throughput capacity is reached from spring through to the fall. Table 3 summarizes the system throughput and yields for 2014 and 2015.

Table 3: System Throughput and Yield

	2014		**2015**	
	Annual Tonnes	**Average Tonnes per Hour**	**Annual Tonnes**	**Average Tonnes per Hour**
Tonnes Glass Marketed	1,964	1.63	2,697	2.04
Tonnes Process Residue	1,276	1.06	1,908	1.44
Total System Throughput	3,240	2.7	4,605	3.48
System Yield	**61%**		**59%**	

Notes:
1) System run time in 2014 was approximately 1200 hours due to installation and commissioning of new equipment.
2) System run time in 2015 was approximately 1320 hours. Dryer issues resulted in some downtime and lower system throughput in the 1st quarter of 2015.

3.3 Trommel and Aspirator Performance

As noted above, the trommel and aspirator perform two of the eight steps that remove residue from the MBG stream. Combined, the eight steps remove approximately 1,130 kgs per hour of residue (e.g., paper, plastic, metal and glass fines) from the system (based on 2015 production). The trommel removes approximately 207 kgs of residue per hour, and the aspirator removes approximately 26 kgs per hour of light paper plastic and collateral glass. Combined, this represents 21% of the total input residue stream. The magnetic separators, screens and other air separation systems remove the remaining 79%.

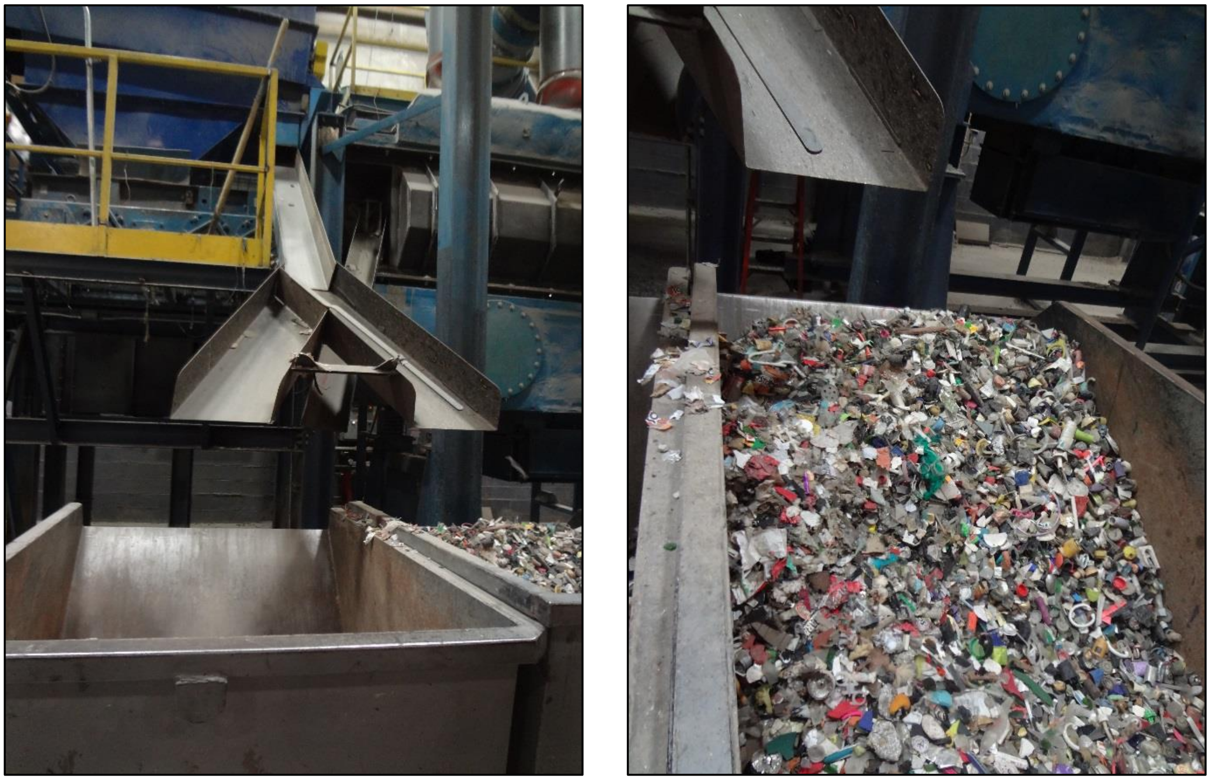
The composition of trommel screenings were audited three times over a 12-month period. The total weight of trommel screenings sampled was 61.5 kg. The sample sizes ranged from 17 kg to 24 kg. The sampled trommel screenings consisted of glass > ¼” in diameter (39.1%), 1.1% sieve glass < ¼” in diameter (1.1%), metal (9.2%), and 50.6% other miscellaneous residue (including plastics and other residue). Table 4 presents the composition of the glass feedstock samples. Figure 2 depicts the trommel, and Figure 3 shows the trommel chute and examples of trommel residue.

Table 4: Trommel Screen Audit Results

Trommel Screen Composition (Percentage)	Dec. 18, 2014	April 9, 2015	July 7, 2015	Weighted Average
Glass >1/4"	57.0%	36.4%	17.1%	**39.1%**
Sieve Glass <1/4"	1.9%	1.1%	0.0%	**1.1%**
Metal	2.8%	10.2%	17.1%	**9.2%**
Other	38.3%	52.3%	65.8%	**50.6%**
Total	**100%**	**100%**	**100%**	**100%**
Sample Size (kg)	24	20	17	61

Figure 2: Trommel Screen

Figure 3: Trommel Screen Chutes and Residue



The fan for the aspirator has an adjustable damper, which the MRF has set at the low end. The MRF operators have the flexibility to double the airflow in order to remove more contamination from the stream, but finding the right balance between contamination removal and product removal is key; removing too many glass fines would result in accelerated wear of the piping and cyclone.

After installation, there were some fine-tuning and other adjustments required of the GCS equipment. For instance:

- **Trommel:** The trommel unit included a cleaning brush that would turn along the outside face of the trommel screen deck. This brush would frequently clog with fine glass and grit, resulting in labour-intensive removal and cleaning. Additionally, the brush was not effective in removing larger debris, such as string, rope and wire, and would cause the 3/4” holes to clog with fine debris. Consequently, the cleaning brush was removed and the trommel screen was opened once per week to manually remove all built-up debris, requiring approximately only 30 minutes of staff time.
- **Bucket Elevator:** The bucket elevator unit jammed on a daily basis due to glass wedging between the conveyor belt and the solid tail pulley, resulting in about 20 minutes of downtime per day. In June 2015, a new self-cleaning pulley was installed to prevent this from occurring. A new conveyor belt and buckets were installed in January 2016 due to wear and tear from the

glass. As a result, downtime has been reduced to routine inspections to ensure the belt is tracking properly on the pulley.

- **Aspirator:** The aspirator, which has no moving parts, is inspected throughout the day to ensure there are no jams or product impeding the exit ports. The aspirator jams two to three times per day when using wet feedstock, as clumps of paper build up prior to the aspirator and jam the aspirator ports. Approximately 20 minutes of staff time are spent daily ensuring smooth operation of the aspirator. The aspirator does not have to be shut down for these inspections and debris removal.

4 Financial Implications

4.1 Capital Costs

The total budgeted capital cost of the GCS was $252,607, including equipment, installation, electrical, commissioning, and administration (Table 5).

Table 5: GCS Budgeted Capital Costs

Item	Budget
Cost and Installation of Equipment	$120,827.54
Addition of Magnet	$24,193.44
Installation of Magnet	$4,706.40
Commissioning and final payment	$63,879.43
Engineering and Contract Administration	$9,000.00
Electrical	$30,000.00
Total	$252,606.81

4.2 Cost Savings Potential for Managing Stockpiled MBG

As noted previously, prior to the installation of the GCS, the Region was shipping its MBG at a cost of about $28-30 per tonne and importing clean glass to produce its EcoGlass product. The closure of the third party processing facility forced the Region to pursue alternative markets and options to handle its MBG. The estimated cost to ship the Region's MBG to a third party processing facility, had they been able to receive it, would have been $45 per tonne. Another option would have been to dispose of the Region's MBG at a cost of about $70 per tonne. This led the Region to begin stockpiling its MRF MBG for eventual processing through the MRF's glass plant to produce the EcoGlass product. A total of 3,815 tonnes were stockpiled at the Fort Erie landfill site at a cost of $19,075 (includes freight cost of $5 per tonne; there are no other costs for storage).

Since the installation of the GCS, the Region has been able to discontinue stockpiling its MBG, process the stockpiled MBG and stop the purchase of the cleaned glass for use in the EcoGlass system. As Table 6 presents, the GCS investment will provide the Region with an estimated $236,500 in net savings, in addition to avoided costs from the potential purchase of cleaned glass.

Table 6: Potential Cost Savings (Stockpiled MBG)

Item	Cost / tonne	Tonnes	Cost
Costs			
Transport of Stockpiled Material to MRF for Processing	$8	3,815	**$30,520**
Savings			
Disposal of MBG	$70	3,815	**$267,050**
Net Costs / Savings			**Savings of $236,530**

Note: Cost savings do not include avoided costs of purchasing cleaned glass for use in EcoGlass process.

4.3 Potential Economic Benefits

The Region's existing MBG stockpiles will be exhausted by the end of 2016 or early 2017. At that stage, Niagara Region will seek new sources of MBG from other municipalities or MRF's capable of providing MBG within the desired specifications. This would provide an additional revenue stream for the Region's recycling program, as well as avoided costs from the disposal of its MBG. As Table 7 presents, the GCS will provide a net annual economic benefit of more than $150,000 from the additional revenue stream and avoided MBG disposal costs.

Table 7: Anticipated Annual Economic Benefits

Item	Totals (annual)
Potential Annual Revenue	
Capacity of Throughput (based on 2015 throughput)	4,605 tonnes
Tonnage of throughput from residential/commercial sector and other contracts	3,339 tonnes
Throughput of Stockpiled MBG	850 tonnes
Potential Remaining Capacity (once stockpile is processed)	850 tonnes
Potential Revenue per Tonne	$10/tonne to $15/tonne (average: $12.50/tonne)
Potential Annual Revenue	850 tonnes x $12.50/tonne = **$10,625**
Potential Annual Avoided Disposal Costs	
% Yield of glass cleaning process (average of 2014 and 2015 performance)	61%
Annual Tonnes of Niagara MBG Processed into Eco-glass (and therefore not disposed)	3,339 tonnes x 61% yield = 2,037 tonnes
Avoided Annual Disposal Costs (@ $70/tonne)	2,037 tonnes x $70/tonne = **$142,575**
Anticipated Annual Economic Benefit from GCS	$10,625 annual revenue + $142,575 avoided disposal costs = **$153,200**

4.4 Operating Costs

The estimated cost to operate the GCS based on electricity costs is approximately $17 per day (assuming a unit electricity cost of 11 cents per kWh). Table 8 presents the electrical specifications of the new equipment and estimated electrical costs to operate the system.

Table 8: Electricity Costs for New Equipment

New Equipment	Electrical Specification	Usage	Rate	Hours per day	Cost per Day
Trommel Screen	2 hp, 30 rpm	2.8 kw	$0.11 kwh	6 hours	$1.85 / day
Bucket Elevator	3 hp, 175 rpm	4.0 kW	$0.11 kwh	6 hours	$2.64 / day
Rotary Airlock	1 hp, 25 rpm	1.5 kW	$0.11 kwh	6 hours	$1.00 / day
Aspirator Fan	15 hp, 1,800 rpm	17.7 kW	$0.11 kwh	6 hours	$11.68 / day
Total					**$17.17 / day**

4.5 Estimated Investment Payback

The estimated payback period for the GCS investment was calculated based on tonnes of MBG processed, avoided disposal costs, operating costs, and budgeted capital cost. Assuming a start-date of April 2014, the estimated payback period for the $252,607 investment is 17 months. Table 9 presents the basis for the payback estimate. In calculating the payback period, assumptions included:

- The economic benefit from processing the Region's MBG is the avoidance of the MBG's disposal, at an assumed cost of $70/tonne;
- The start-date for the equipment was April 2014;
- The throughput tonnage for 2014 (3,240 tonnes) was distributed uniformly across April 2014 to December 2014, at 360 tonnes per month;
- The throughput tonnage for 2015 (4,605 tonnes) was distributed uniformly across 2015, at 384 tonnes per month;
- Yields for 2014 and 2015 were 61% and 59%, respectively;
- Avoided disposal costs were applied only to MBG processed into EcoGlass; residue was assumed to have been disposed; and
- Freight costs to ship stockpiled MBG to the MRF have not been included, as it is unclear how much of the feedstock would be stockpiled MBG and how much is new curbside-collected MBG.

Table 9: Estimated GCS Investment Payback Period

Year	Month	Feedstock Throughput (monthly) tonnes	Residue, monthly (based on yield) tonnes	MBG Avoided Disposal (monthly) tonnes	MBG Avoided Disposal Costs (@ $70/tonne)	Operating Costs (Average Monthly Electricity Cost)	Net Monthly Cost Avoidance	Cumulative Economic Benefit	Cumulative Economic Benefit against Capital Investment of $252,607
2014	Apr	360	140	220	$15,372	$373	$14,999	$14,999	$237,608
	May	360	140	220	$15,372	$373	$14,999	$29,998	$222,609
	Jun	360	140	220	$15,372	$373	$14,999	$44,997	$207,610
	Jul	360	140	220	$15,372	$373	$14,999	$59,996	$192,611
	Aug	360	140	220	$15,372	$373	$14,999	$74,995	$177,612
	Sep	360	140	220	$15,372	$373	$14,999	$89,994	$162,613
	Oct	360	140	220	$15,372	$373	$14,999	$104,993	$147,614
	Nov	360	140	220	$15,372	$373	$14,999	$119,992	$132,615
	Dec	360	140	220	$15,372	$373	$14,999	$134,991	$117,616
2015	Jan	384	157	226	$15,849	$373	$15,476	$150,466	$102,140
	Feb	384	157	226	$15,849	$373	$15,476	$165,942	$86,664
	Mar	384	157	226	$15,849	$373	$15,476	$181,418	$71,189
	Apr	384	157	226	$15,849	$373	$15,476	$196,894	$55,713
	May	384	157	226	$15,849	$373	$15,476	$212,370	$40,237
	Jun	384	157	226	$15,849	$373	$15,476	$227,846	$24,761
	Jul	384	157	226	$15,849	$373	$15,476	$243,322	$9,285
	Aug	***384***	***157***	***226***	***$15,849***	***$373***	***$15,476***	***$258,797***	***-$6,191***

5 Lessons Learned

The GCS is performing well to process the Region's MBG, and the product exiting the GCS is of very good quality (Figure 6 depicts a sample of glass pulled from the aspirator). Lessons learned and advice for other municipalities considering a GCS are:

Aspirator

- In terms of transferability to other MRF's, there are some key issues that should be considered. The aspirator design should consider the feedstock size in order to minimize the amount of collateral glass removed with the contaminants. The MRF's installed aspirator is separating a stream ranging from 3/4" to dust. Based on the desired outcome for the marketable product, ideally the system should have two aspirators, with one to produce glass particles 3/4" to 3/8" and a second to produce glass particles 3/8" to dust. This would ensure maximum contamination recovery with minimum glass loss.
- The aspirator is located after the dryer in the Niagara GCS system. In a typical MRF process, drying may not be an option, so the MBG would be subject to wet conditions. The system would then be prone to significantly more jamming due to paper build-up. Easy access doors for cleaning the aspirator are therefore very important. Since more air volume will be required under wet conditions, the aspirator should come equipped with a variable frequency drive.
- The efficiency of the aspirator depends on flow of material. If there is not enough flow, then the product (i.e., glass) will get sucked out as well.
- The feedstock should be kept as dry as possible, as material can jam in the aspirator if it is wet, and it can be expensive to dry wet MBG.

Trommel

- The trommel screen in the Region's application is located after the glass is ground to less than 3/4". In a MRF process, the trommel would have openings of 2" to 3", depending on the type of glass breaker screen used.
- Depending on the quality of a MRF's MBG feedstock, a trommel screen may not be required. However, if the glass is very contaminated it may useful to have a trommel screen before the aspirator in order to remove long items such straws or strings, as these can be problematic in the aspirator (i.e., they can jam or get caught up in the aspirator baffles).

Other Lessons Learned

- The magnet process did not work as well as expected. The key issue with the magnet was that too much glass was removed along with the metal.
- Elevation of the equipment is key to ensuring the system runs efficiently and cost effectively. Ensure there is sufficient height in your facility so that the equipment can allow gravity to help in the process.

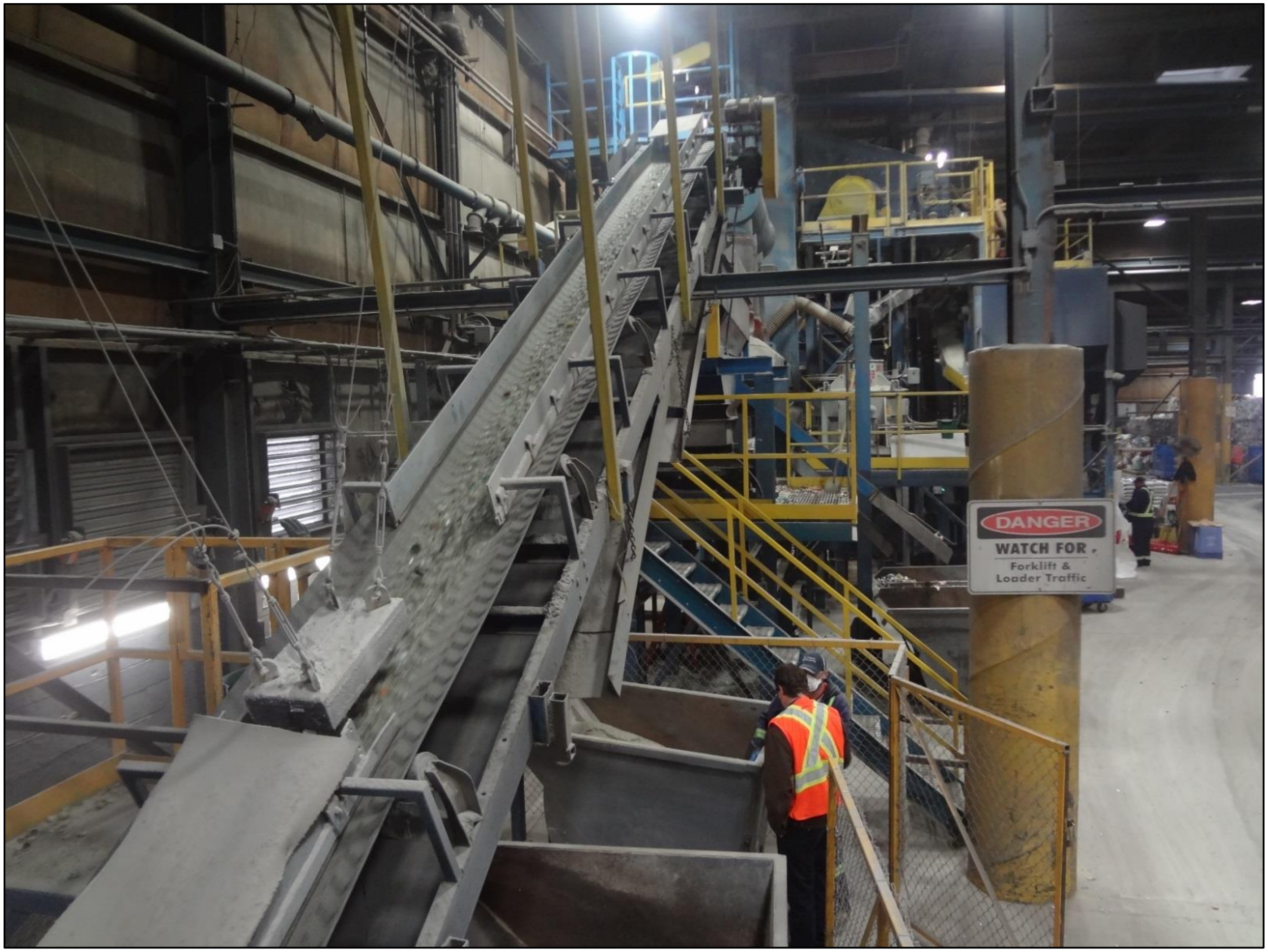
6 Conclusion

For Niagara Region, the GCS installed at their MRF has benefited its recycling program. With a trommel and an aspirator (or two), MRF's will be able to achieve a considerably higher quality MBG with a reasonable capital investment.

A GCS may be suitable for municipalities wishing to provide a more marketable MBG product for the recycled glass marketplace. Factors that would influence the economic feasibility of a GCS for a municipality may include existing processing and disposal costs of MBG, potential for added revenue from the recycled glass marketplace from a cleaner MBG product, and potential increased processing efficiencies.

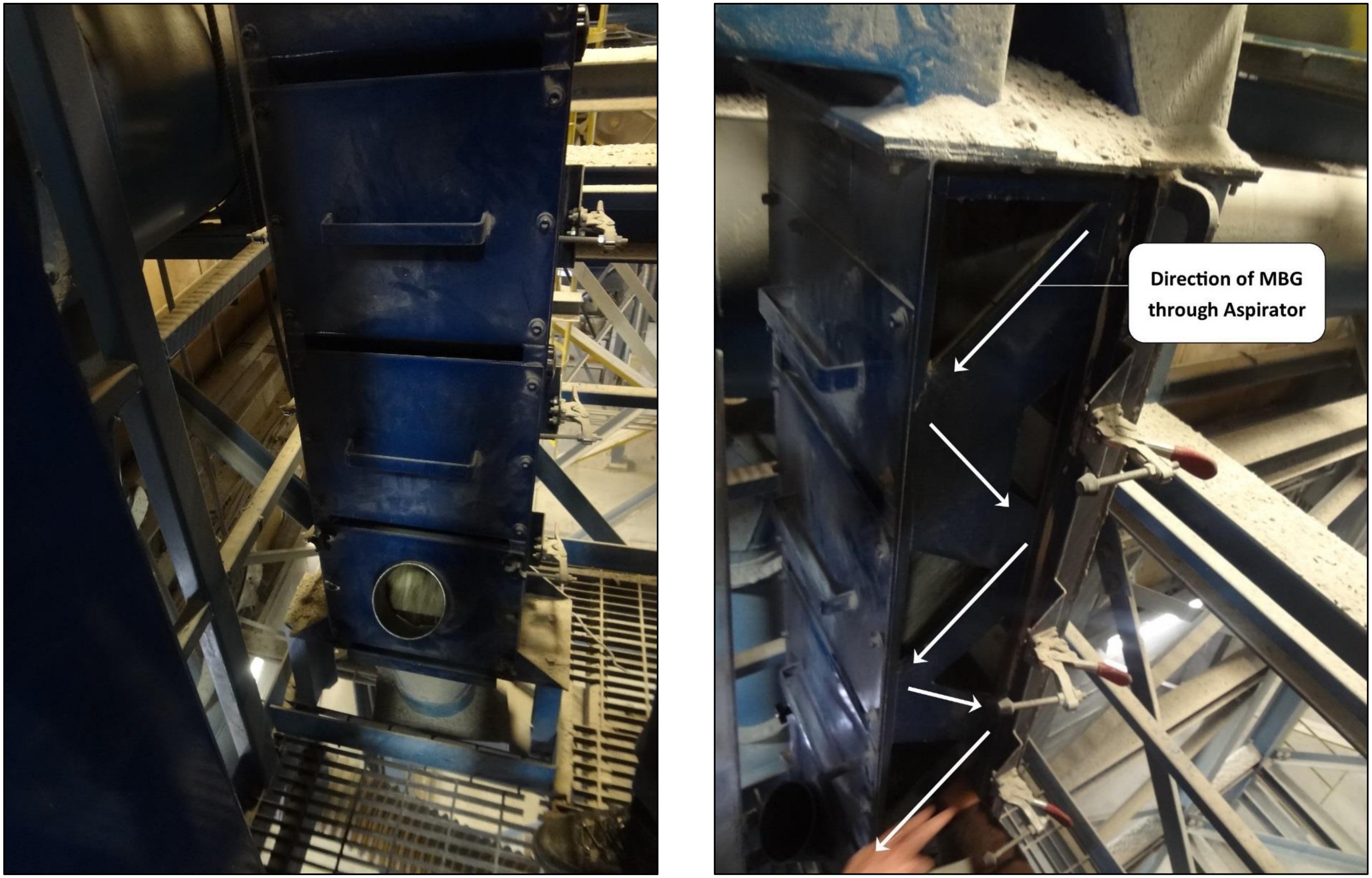
Appendix A: Additional Figures

Figure 4: MBG Conveyor Belt



MBG is elevated via conveyor belt into the GCS. Conveyor belt part of the GCS upgrade.

Figure 5: GCS Aspirator



Front and side views of aspirator. Image on right shows direction of travel of MBG through aspirator (side panel removed). Part of the GCS upgrade.

Figure 6: Sample of Glass Pulled from Aspirator Unit

Sample of MBG pulled from aspirator unit.

Figure 7: Updated Control Panel

Updated control panel. (Right – wide view; left – close up). Part of the GCS upgrade.