Appendix E

New and Emerging Initiatives and Technologies in Waste Management

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Introduction

York Region and its nine local municipalities, delivers programs and services to almost 1.2 million residents, across 377,000 households. Currently, residents have access to curbside collection of residual waste, single-stream recycling, organic waste and yard waste (seasonal). These waste streams are collected by the local municipal partners and delivered to one of the Region's facilities or contracted service providers;

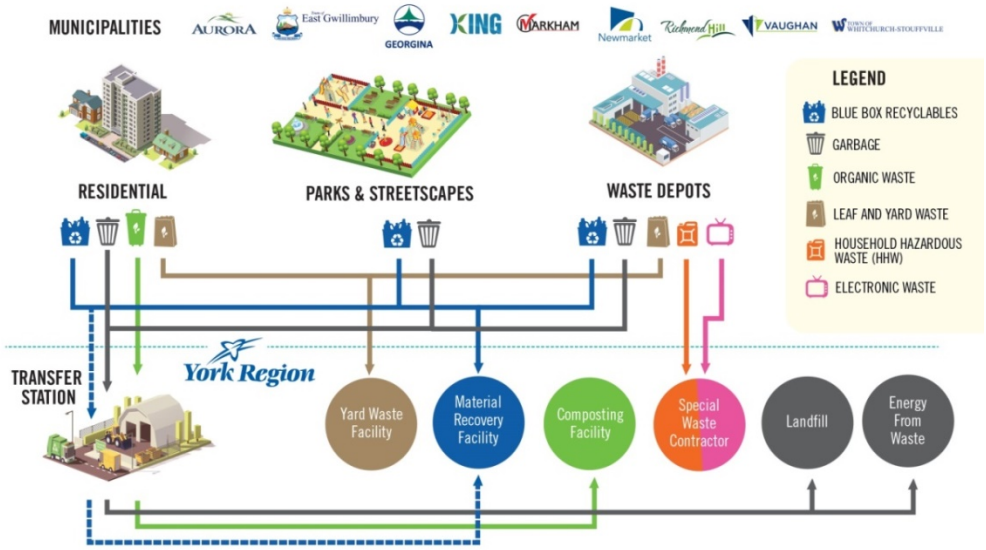
- Transfer station;
- Material recovery facility (MRF);
- Energy-from-waste (EFW); or,
- Organic waste processing facilities.

In addition to curbside collection, residents also have access to Waste Depots or Community Environment Centers (CECs) where additional types of waste can be disposed or diverted including:

- Electronic waste (E-waste)
- Household hazardous waste (HHW)
- Scrap Metal/Metal Appliances
- Cooking oil
- Clothing/Textiles (new program)
- Residual waste
- Recyclables
- Yard waste
- Construction waste

Figure 1 illustrates the type of materials accepted and collected by the local municipal partners, as well as the transfer and processing services provided by York Region.

Figure 1: Waste Flows within York Region and its Local Municipal Partners



Recognizing the growing demand on its waste management services, York Region along with its nine local municipal partners developed its Integrated Waste Management Master Plan (SM4RT Living Plan) in 2013. The SM4RT Living Plan identified more than 60 initiatives to improve sustainability of the waste system in the Region over the next 25 to 40 years.

As part of the 5-Year review of the SM4RT Living Plan, York Region retained EcoCompass Inc. to conduct a jurisdictional and market scan of new and emerging technologies and initiatives within the waste management industry. The objective was to identify both short-term (quick-wins) and long-term initiatives and technologies that have been implemented or introduced since the initial development of the SM4RT Living Plan. This report groups the technologies and initiatives into four categories:

- General;
- Curbside Collection;
- Public Space and Public Drop-Off Collection; and,
- Waste Processing and Sorting.

For each category, EcoCompass identified applicable technologies and initiatives for York Region based on its ability to meet one or more of the Region's five key priorities:

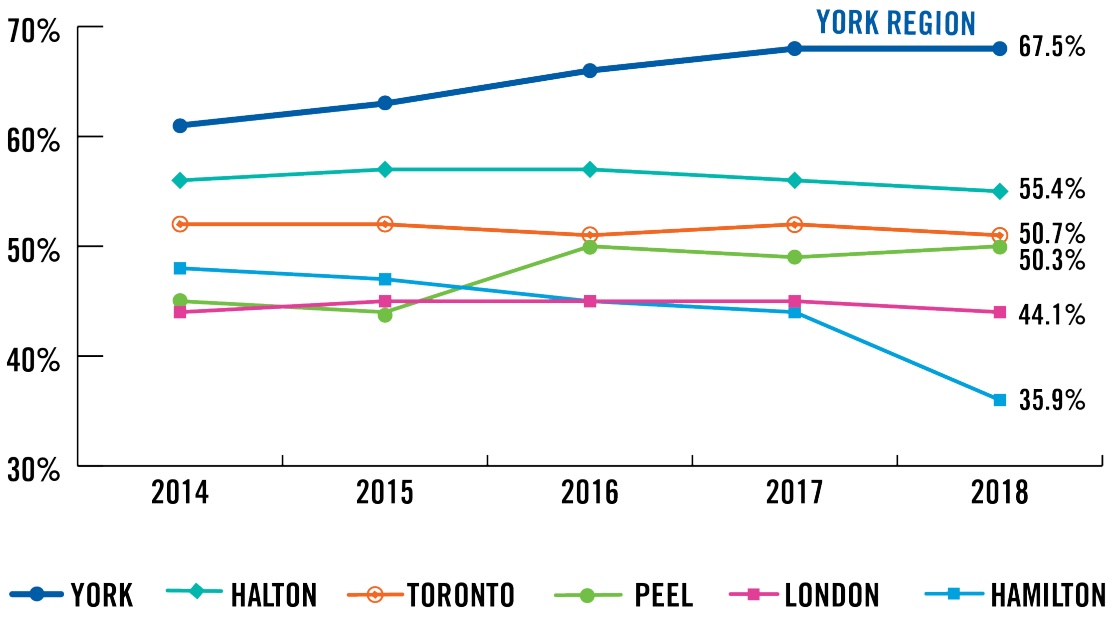
- Reducing GHG emissions;
- Increasing cost savings;
- Increasing overall waste diversion;
- Decreasing contamination within waste streams; and,
- Aligning local policies with provincial and federal policies.

EcoCompass reviewed publicly available studies, white papers, articles and journals to identify initiatives and technologies implemented by various jurisdictions and evaluated the benefits of each approach. The following report summarizes the findings, and identifies whether the technology is ready to be implemented for York Region, or be monitored as the technology or initiative is still developing.

Background

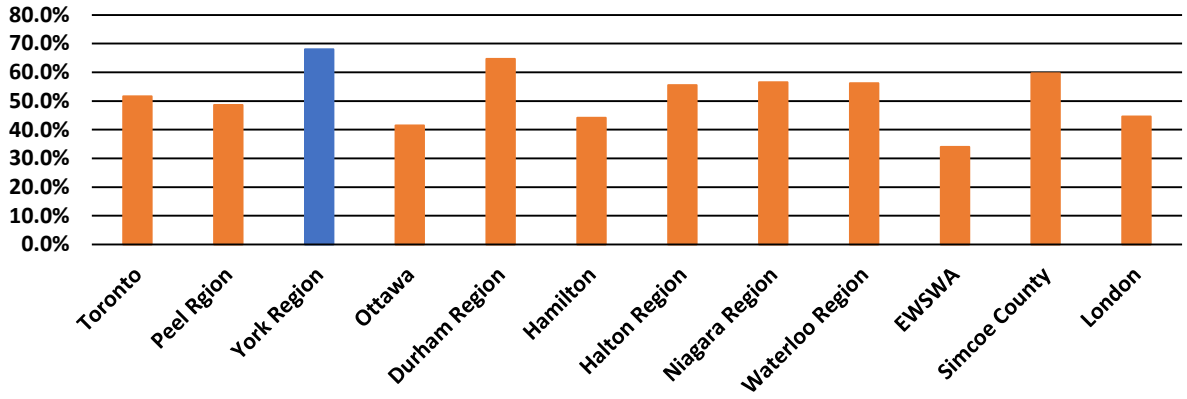
Since the development and implementation of the SM4RT Living Plan, York Region has seen a significant increase in its residential waste diversion rate, growing from 58.6% in 2013 to 67.5% in 2018. This increase in diversion has significantly outpaced other Large Urban (Group 1[1]) municipalities which include the City of Toronto, Peel Region, City of Hamilton, Halton Region, and City of London. As Figure 2 illustrates, the verified provincial diversion rate of municipalities in the large urban category in 2018 ranged between 36% - 55%, compared to York Region's 67.5%. Note: Residential Waste Diversion Rates are calculated annually by the Resource Productivity and Recovery Authority (RPRA) based on data provided by Ontario municipalities through the annual Datacall.

Figure 2: Verified Provincial Diversion Rates Large Urban Municipal Category (2013-2018)



In addition, the 2017 Residential Waste Diversion Rates[2] from RPRA indicate York Region has not only the highest residential waste diversion rate amongst Large Urban municipalities (Group 1), but also the next closest municipal grouping, Urban Regional (Group 2) municipalities, while having almost a 20% higher diversion rate than the City of Toronto and Peel Region (See Figure 3).

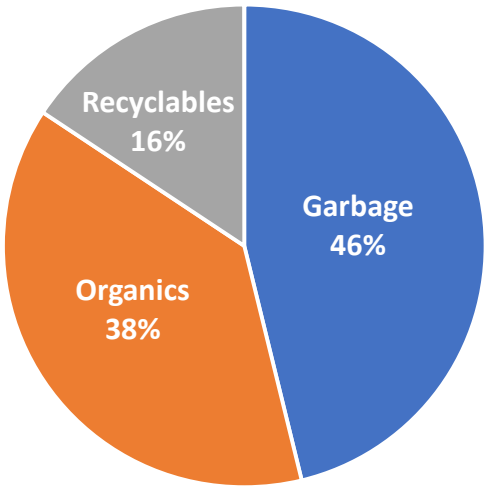
Figure 3: 2017 Residential Waste Diversion Rates Large Urban (Group 1) and Urban Regional (Group 2)



While the Region's residential waste diversion rate has significantly increased from 2013 – 2017, there are still opportunities to improve and further reduce recyclables and organics materials found within residual waste. Based on York Region's 2018 Single-

Family Curbside Waste Audits, organics make up 38% of residual waste, while recyclable materials make up about 16% of residual waste (See Figure 4).

Figure 4: 2018 Waste Composition in York Region's Single-Family Curbside Waste Audit



To address the "avoidable food" found within the residual waste stream, the Region has launched its Good Food Program which provides residents a workshop to help identify different ways of cooking foods and how to effectively reuse leftovers. Reducing food waste not only results in a reduction in costs for the Region as there is less material to process, it also reduces greenhouse gas emissions. Further work must continue in this area to target food waste reduction. In addition, greater diversion of organic materials would significantly increase the Region's overall waste diversion rate. For example, a 50% reduction of these materials would reduce the waste sent to disposal by approximately 14%.

As with any large urban municipality, continued growth in population and densification of areas places a greater strain on delivering waste management services effectively. Additionally, the growing trend of "on-the-go" consumption and convenience-based packaging (i.e. coffee pods, individual wrapped produce) has resulted in more complex materials to be managed both from households as well as in public spaces. For the Region to ensure it can meet its objectives, it must consider technologies and initiatives along the entire waste management supply chain, from how and what types of materials are to be collected to how they are processed/disposed.

New & Emerging Technologies and Initiatives - General

Using Data to Maximize Diversion

Description: Businesses across all industries are using large data sets, sometime referred to as Big Data, to identify trends and solve complex problems. While the use of Big Data has typically been synonymous with banking, retail, manufacturing, etc., its uses have expanded into the waste management industry. Technological advancements have enabled the waste industry to integrate various measuring and monitoring tools into everyday activities. As an example, the Region tracks the number of visitors and types of requests made through its Bindicator app. This enables the Region to identify materials that residents are often confused about and to customize promotion and education initiatives aimed at addressing these materials.

In 2014, Stockholm used Big Data to track over 500,000 data entries consisting of the amount and unit of waste, type of waste, collection data, disposal sites, waste management company and waste management license number to optimize waste collection routes[3]. This enabled Stockholm to visualize waste generation and determine if trucks should be rerouted to maximize waste collected before offloading its materials, thus reducing GHG emissions and operating costs. Similarly, technology developments in waste bins, creating smart bins, allow for real-time data on the fullness of bins to be provided back to collectors. This information can significantly reduce collection costs by eliminating unnecessary collection trips.

Another area, where data and technology intersect is the use of block chain technology. It effectively is a unique time-stamped transaction that can't be copied or falsified. In the context of waste management, block chain is an effective tool at tracking waste from a collection site to a final disposal site. It can allow users to track recyclables materials and/or hazardous materials to ensure their proper recycling/disposal by tracking all of the transactions involved within the supply chain. While this technology has shown promise, York Region or its local municipal partners may not directly utilize this technology. However, as Ontario transitions to full producer responsibility, the responsibility for safely and effectively recycling and disposing of material will fall on the producers, who may consider this technology to minimize their risks.

Meeting Region Objectives:

- ✓ Reducing GHG emissions – by optimizing operations, specifically with collection, can reduce the amount of fuel used to deliver waste management services
- ✓ Increasing cost savings – by reducing fuel consumption and improving collection efficiencies that reduce operating costs. This technology can be used to customize messaging and improve enforcement further reducing costs.
- ✓ Increasing overall waste diversion – by customizing solutions based on specific issues and trends to improve overall diversion and capture of materials.

Opportunity: Collecting relevant data will be vital for the Region and its local municipal partners to address specific waste management issues. The use of RFID technology, currently deployed within several of the local municipal partners, and smart bins in public spaces and/or multi-residential buildings can provide critical information that can enable municipal partners to optimize collection routes and target problematics and materials. As these technologies develop, the Region should continue to monitor and undertake a more detailed assessment on identifying opportunities for tracking waste data.

As Ontario transitions to full producer responsibility, municipalities will still be responsible for the management of the residual waste stream and organics stream. However, as other obligated materials are still collected within the Region, it will be beneficial for the Region to advocate for transparency in how and where materials collected from the Region are recycled and/or disposed. Advocating for the use of block chain technology may be one avenue where the Region and its local municipal partners can be assured their materials will not end up illegally dumped or sent to facilities with poor environmental or health standards. Block chain technology can be used as a tool by producers to track performance against targets and leverage the data to meet reporting requirements. Reporting requirements will need to be defined under the regulations so there is an opportunity for municipalities to advocate for use of this tool and ensure information collected is reported publicly to ensure transparency.

New & Emerging Technologies and Initiatives for Household Collection

Cart-Based Collection

Description: York Region is the third largest municipality in Ontario, behind the City of Toronto and Peel Region based on population size. All three municipalities provide residents with residual waste, single-stream recycling and organics collection; however, York Region is the only municipality of the three to collect residual waste via bags and/or cans, and recyclables via Blue Boxes. The other two municipalities transitioned to cart-based collection for all waste-streams; the City of Toronto transitioned in 2007, while Peel Region transitioned in 2016.

Cart-based collection provides several benefits as it has been shown to increase participation, increase capture rates, reduce collection costs, reduce litter, and improve collector safety. Cart-based collection can enable municipalities to move towards a utility-based fee model, where residents are charged based on the size of garbage bin selected; the greater the size, the greater the cost to residents. A utility-based fee model can incentivize residents to reduce waste and maximize waste diversion. For example, Toronto implements a utility-based fee model providing residents one of four cart sizes for residual waste collection; Small (75 L; equivalent to 1 garbage bag), Medium (120 L;

1.5 bags), Large (240L; 3 bags), and Extra-Large (360 L; 4.5 bags). Residents electing to use the Small garbage cart will pay an annual fee of $266.24 per year in 2020, while residents selecting the Medium size, the next size larger, will pay more than double the cost at $323.20; cost for a Large cart is $438.96 and an Extra-Large cart is $509.15. Cost for recycling and green bin is free. The linking of a fee directly to the cart size selected provides a significant incentive for residents to first minimize their waste, and then to identify ways to maximize their diversion using existing programs. This could result in reducing the amount of recycling and organics found in the garbage stream as shown in Figure 4.

The greatest risk associated with cart-based collection is higher contamination levels within the recycling stream. Toronto and Peel, which provide single-stream cart-based recycling collection to residents, have experienced contamination rates over 25%. As Ontario will be transitioning the Blue Box program to full producer responsibility, this issue may be more of a concern for producers than York Region and its local municipal partners. Producers will be responsible for providing appropriate promotion and education is provided to York Region residents, to minimize contamination and ensure only appropriate materials are being recycled.

Meeting Region Objectives:

- ✓ Increasing cost savings – by reducing the number of operators required to collect materials and increasing the efficiency at which collection can occur.
- ✓ Increasing overall waste diversion – by moving to a utility-based model, residents can be incentivized to increase waste diversion.

Opportunity: York Region and its local municipal partners to study the impacts of transitioning garbage collection to a cart-based program with the intent of utilizing a utility-based fee model. Resident should be incentivized through low fees for smaller carts and higher fees for larger carts. However, Toronto recently raised the fee for the small cart in an effort to minimize residents from purchasing the small cart to save money and load up their recycling and organics carts with residual waste. The small cart fee is still lower than the larger carts, however, the rate more than doubled from the 2019 fee of $99/year to over $260/year in 2020. Toronto staff continue to monitor and improve the effectiveness of the cart-based program. As some of the local municipal partners have recently entered into new collection contracts, it is recommended the local municipalities use this time to study the costs and impacts of transitioning and developing an appropriate fee model prior to entering into the next round of collection contracts. Additionally, as Ontario transitions the Blue Box program to producers, it will be important for York Region and local municipalities to advocate for a broader range of materials to be recycled by producers or risk having certain packaging find its way into the residual waste stream.

Electric Trucks/Vehicles

Description: In 2013, the Ontario Ministry of Environment identified transportation as the largest contributor to GHG emissions, at 35% of the total emissions, ahead of industry at 28% and buildings at 19%[4]. In an effort to combat these emissions, almost all automotive companies now offer a range of electric vehicles, with some companies like Tesla, that offer exclusively electric vehicles only. Advancements in electric batteries and technology have enabled expansion of this technology into medium and larger trucks, including waste collection trucks. Companies such as Peterbilt, Volvo and Mack, all providing waste collections trucks have recently introduced electric power waste collection trucks.

Seattle made history earlier this year when its waste collection service provider, Recology, received and operated the first fully electric collection vehicle in 2019. Similarly, Renova in Hamburg, Germany purchased the first electric waste collection trucks from Volvo and they are expected to be in operation in the second half of 2019[5]. New York City, Los Angeles, Sacramento, and several other Asian and European markets are poised to introduce electric vehicles for waste collection.

Garbage trucks appear to be best suited for conversion from an internal combustion engine to electric, as they tend to drive at slower speeds and make frequent stops. Additionally, as they follow predetermined routes, it enables drivers to have a better sense on expected driving range of their trucks. Companies also tout other benefits of electric trucks including reduced noise pollution and lower maintenance costs.

Meeting Region Objectives:

- ✓ Reducing GHG emissions – by eliminating the need for fossil fuels to power collection trucks.
- ✓ Increasing cost savings – by offsetting higher infrastructure and capital costs, with lower maintenance and fuel costs.

Opportunity: Since the Region and its local municipal partners do not own the current collection fleet, the opportunity lies in collaborating with the current service provider of the local municipal partners to pilot or launch these vehicles. This would be similar to Seattle, who contracts Recology to provide collection services, and only launched a single electric truck as a pilot with a second one to be introduced in 2020. While specifics on the cost of the pilot have not been provided, Recology VP indicates that electric vehicles have a higher capital infrastructure cost but can have lower refueling costs (depending on electricity and fuel rates) and lower maintenance costs. As this technology has only been deployed in 2019, it will be prudent for the Region to continue monitoring the development and effectiveness of these trucks in the coming years.

Autonomous Collection Trucks

Description: In 2017, Volvo launched a joint venture with a Swedish waste management company, Renova, to test autonomous collection trucks[6]. The project was

intended to explore how self-driving trucks can be optimized to “enhance traffic safety, improved working conditions and lower environmental impact”. Contrary to the project title, the Volvo trucks still require human interaction to complete the collection of garbage in a given area.

A driver is required to drive the truck to the start of the collection route. Once at the collection route, the truck is entered into its autonomous mode where sensors enable the truck to stop at each house for waste to be picked-up. The truck effectively reverses from the starting point enabling the collector to line up waste containers to be loaded into the back of the truck. Once the truck is full or the route has been completed, the collector drives the truck to the disposal site.

The trucks were designed to optimize speed, steering and gear changing to maximize fuel efficiency and minimize emissions. Additionally, sensors are all around the truck to enhance the safety of collectors and the general public. The latest update from Volvo regarding its technology was in 2018, suggesting this technology hasn’t been picked up by other municipalities.

Meeting Region Objectives:

- ✓ Reducing GHG emissions – by optimizing driving speeds, steering and gear changing it can reduce fuel usage.
- ✓ Increasing cost savings – by reducing fuel usage as well as improving collection efficiency and safety.

Opportunity: As recent shortages of truck drivers, and developments in autonomous driving expands to the transportation industry, it is possible this technology may gain further traction for use within the waste management industry. York Region should monitor this technology as it develops and consider an assessment of its transfer stations and other waste management infrastructure to determine if any modifications would be needed to make these facilities compatible with autonomous waste collection or long-haul transportation vehicles.

Underground/Automated Waste Collection Systems

Description: Underground/Automated Waste Collection Systems use pneumatic (air suction) systems to transport waste disposed at bins to a centralized location through a series of underground pipes. This system minimizes the “above ground” storage requirements for waste collection and eliminates the need for collection trucks to drive from bin to bin. However, the system doesn’t eliminate all trucks as transfer trailers are required to transfer the material from the centralized location to a disposal site.

Automated Waste Collection Systems have been around since the 1970’s. The first installation of an automated waste collection system was at Disney World, FL which is still in operation. Additionally, the first residential installation was on Roosevelt Island, New York, USA in 1975 which still handles approximately 10 US tons of waste on a daily basis. The technology can also minimize the impact of severe weather events or

work stoppages on waste collection. In 2010, New York experienced a severe snowstorm where garbage trucks were used to plow snow. It took the City three weeks to catch-up on garbage collection while residents on Roosevelt Island were unaffected. Since then several communities across the globe have installed automated waste collection systems.

This technology can be beneficial to reduce traffic issues in densely populated areas, or in communities with narrow streets that may be a challenge for collection trucks. The system has been shown to have both direct and indirect benefits to reducing GHG emission.

Meeting Region Objectives:

- ✓ Reducing GHG emissions – by eliminating curbside collection trucks from the road as materials are collected through the networks of pipes.
- ✓ Increasing cost savings – by eliminating the cost associated with purchasing, maintain and operating curbside collection trucks to service residential and businesses.

Opportunity: Automated underground waste collection systems can significantly reduce GHG emissions associated with collection and increase storage capacity of waste materials while also having a smaller "above ground" footprint. The technology can be ideal for multi-residential complexes or older communities with narrow streets. As Markham undertakes the implementation of the Langstaff Master Plan Project[7], which aims to have comparable development density, with residential housing, services, and amenities, typically seen in downtown Toronto, it provides a unique opportunity to explore automated underground waste collection systems and potentially incorporate them into the development. Two key aspects of success for this project will be to maximize space, while optimizing transportation networks. The use of this technology can reduce the footprint required at the various buildings for waste collection, while also eliminating the need for collection vehicles that could increase traffic congestion in the project area.

Contamination issues can arise through underground waste collection systems due to the anonymous nature of disposal. Additionally, the system is not ideal for collecting bulky materials, such as cardboard, or glass. It also has a high initial investment cost and requires prior planning to effectively install the system. A 2013 study conducted by New York City suggested initial investments costs in an automated vacuum waste system would cost 30% - 55% more than a conventional collection, even when utilizing existing underground transportation infrastructure to house the vacuum systems[8]. Additionally, two studies completed in 2007 and 2008 had a similar conclusion of the initial investment cost being about 60% greater than conventional collection. It is recommended York Region monitor any new developments with the use of this technology to consider feasibility for the Langstaff Project.

New & Emerging Technologies and Initiatives for Public Space and Public Drop-Off Collection

Public Space Green Bin Collection

Description: A 2018 study by the City of Toronto found that 84% of waste in garbage and recycling bins located next to Dog Off-Leash Areas consisted of organic waste (pet waste[9]). As pet waste is an acceptable material in the City's Green Bin program, the City installed Green Bins in all dog off-leash parks to capture pet waste and reduce the amount of organic waste going to landfill. Similarly, other municipalities such as Waterloo[10] and Vancouver[11], have installed dedicated bins to collect pet waste in public parks that are frequented by pet owners.

Meeting Region Objectives:

- ✓ Reducing GHG emissions – by minimizing organic waste sent to landfills where it decomposes into methane, a GHG
- ✓ Increasing overall waste diversion – by processing pet waste with green bin materials and avoiding disposal of these materials.
- ✓ Decreasing contamination within waste streams – by promoting the use of a green bin to dispose waste, it will limit the likelihood of pet waste from contaminating recyclable materials.

Opportunity: Similar to the City of Toronto, pet waste is already accepted in York Region's Green Bin program. Providing dedicated Green Bin in parks, specifically dog parks, would enable the Region and its local municipal partners to not only increase waste diversion within the Region at a relatively low cost, but can also serve as a reminder to residents that pet waste belongs in green bins. Green bins should be paired with garbage and recycling bins within parks to minimize cross-contamination between the streams.

Solar Compacting Garbage Bins

Description: As consumer packaging trend towards on-the-go consumption, municipalities are seeking to expand public space waste and recycling infrastructure to minimize litter and to increase diversion. However, unlike residential collection, public space recycling varies significantly on a daily basis, and storage space can be limited. It creates logistical challenges for collectors, frequent collection of partially full bins is costly and energy intensive, while infrequent collection can lead to overflowing bins resulting in litter issues. Several municipalities have installed solar compacting garbage bins in public spaces, streetscapes, and parks to maximize storage and reduce collection costs.

The bins use solar power to compact waste enabling greater storage of waste within a smaller footprint, reducing the number of collections required. Additionally, smart monitoring

technology only sends notification when the bin is full, ensuring bin are only serviced when they need to be, preventing materials from overflowing. One of the leading providers of solar compacting garbage bins, BigBelly[12], suggests their systems can increase storage capacity by up to 8x of a traditional bin and can reduce collection costs by 75%. Cities such as Markham, ON; Winnipeg, MB; Philadelphia, PA; New York City, NY; are a few of the cities that have installed solar compacting garbage bins.

Meeting Region Objectives:

- ✓ Reducing GHG emissions – by optimizing the servicing of these bins and eliminating unnecessary emissions associated with collection.
- ✓ Increasing cost savings – by reducing the frequency for which these bins need to be collected.
- ✓ Decreasing contamination within waste streams – by compacting waste, it increases the capacity and reduces the likelihood of consumers placing waste in recycling containers due to overflowing trash bins.

Opportunity: Solar compacting garbage bins can be a vital tool for the Region to address litter issues, while also reducing collection costs and GHG emissions. Since Markham has already installed these bins along their main street downtown area, the Region can study the effectiveness and opportunities to further deploy these bins throughout the Region. Typically, deployment of these bins should be considered in high traffic/usage areas to minimize the risk of overflowing bins while also reducing the frequency of collection. These bins can also be considered for lower traffic areas, if the areas tend to be more remote and have a high collection cost (travel time) to service the bins.

Collection of Construction, Renovation & Demolition Waste

Description: It is estimated that approximately 400,000 tonnes (2014) of Construction, Renovation and Demolition (CRD) waste is disposed annually in Ontario. GTA communities like Toronto, Peel Region, York Region and Durham Region have seen significant growth and densification which results in increased CRD waste generation. Several municipalities target CRD waste for diversion or special disposal, as these items tend to be bulkier and reduce the ability to maximize landfill space. The City of Toronto has identified CRD waste a prohibitive material[13] and requires the disposal of these materials at their transfer stations. Currently, only clean drywall is targeted for diversion within Toronto.

In 2019, York Region diverted almost 363 tonnes of clean wood and drywall at the Community Environmental Centres and Georgina Transfer Station. The City of Guelph[14] and Ottawa Valley[15] provide residents with additional opportunities to divert certain CRD materials such as unpainted drywall, shingles, wood and concrete. The City of Kawartha Lakes currently accepts clean wood and drywall for recycling[16], and has recently agreed to extend a pilot program to continue the collection of CRD wastes for diversion[17].

Collection of CRD materials has been a challenge for Ontario municipalities due to limited and unstable markets. Items such as clean wood, scrap metal and drywall typically have stable markets; however, these materials are often commingled with other waste which limits the ability to effectively divert these materials. Currently, Try Recycling based in London, ON[18] and Country Wide Recycling based in Hamilton, ON[19] represent two of the larger players for diverting a wide range of CRD materials.

Meeting Region Objectives:

- ✓ Increasing overall waste diversion – by diverting CRD, which tend to be bulky materials and do not lend to compacting as well as municipal solid waste within landfills.
- ✓ Aligning local policies with provincial and federal policies – by collecting a Phase 2 material that has been identified by the Canadian Council of Ministers of the Environment (CCME) for EPR program implementation in the coming years.

Opportunity: While other municipalities have expanded collection of CRD to other materials, these markets have significant challenges and capacity to handle mixed CRD wastes. Given the lack of capacity and investment from industry, and regulations from government, it is not likely to see significant development of market capacity for CRD materials. However, as the CCME have identified CRD materials as part of Phase 2 of materials to be considered for EPR programs, it would be prudent for the Region to advocate for effective policy to divert these materials. The Region should also consider establishing a CRD task force with other local municipalities, focusing on GTA municipalities with similar objectives such as Toronto[20] and Peel Region[21]. The Region can leverage existing groups and associations, Municipal Waste Association (MWA), Association of Municipalities of Ontario (AMO), and Regional Public Commissioners of Ontario (RPWCO) to bring forward these issues and identify partners in pooling resources and consolidating volumes.

New & Emerging Technologies and Initiatives for Waste Sorting and Processing

On-Site Organics Management

Description: In 2017, the National Zero Waste Council estimated almost 2.2 million tonnes of edible food was wasted by Canadians, amounting to a cost of over $17 billion[22]. Food waste that is not diverted through organics programs end up in landfills, where they breakdown and create methane, a greenhouse gas. Greater promotion of organics collection can minimize the waste disposed; however, organics collection tends to be expensive and may be a limited option for some multi-residential or institutional buildings. In these cases, on-site management may alleviate costs while increasing diversion.

Grind2Energy[23] is an on-site solution enabling customers to dispose of all types of food waste, as well as fats, oils and grease (FOGs). The system consists of three

components; the table, the disposer and the holding tank. As food waste is disposed into the table (sink), the waste is grounded into slurry and sent to a holding tank. Once full, a liquid waste hauler transports the slurry to an anaerobic digestion facility.

In the UK, Tidy Planet has developed a range of solutions for on-site food waste management. One of their products, the Rocket Food Waste Composter[24], comes in multiple sizes that enable users to divert anywhere from 50 litres of food per week to 3.5 tonnes per day. Food waste is broken down on-site and the output is a nutrient rich compost. Additional equipment, such as a de-waterer can further increase the capacity of its system.

Another example of an on-site organics' management solution is HomeBiogas. HomeBiogas, funded by the Closed Loop Fund, it provides residents with a system that can accept a wide range of organic materials including fruits and vegetables, meats, dairy products, pet waste, etc. and converts these materials into a biogas. The system can be connected to a stove that enables the conversion of the biogas produced to be used by the resident. This technology requires a fairly large footprint and would ideally be deployed in rural households or a large community center with significant food prep.

Meeting Region Objectives:

- ✓ Reducing GHG emissions – by reducing the fuel used by collection trucks to pick up organic waste from these buildings. Also, some of the technologies convert it into a gas than be used by the consumer, further reducing/offsetting electricity or gas required for cooking or power.
- ✓ Increasing cost savings - by eliminating the need or reducing the frequency of collection.
- ✓ Increasing overall waste diversion – by diverting organic waste away from landfills and producing compost that can be used.
- ✓ Decreasing contamination within waste streams – by providing organics collections to communities that might be underserviced through the organics program (i.e. rural communities, community centers).
- ✓ Aligning local policies with provincial and federal policies – by addressing food waste which the Ontario government has indicated it will be addressing through its Ontario's Food and Organic Waste Policy Statement[25] and Action Plan[26].

Opportunity: Food waste not only contributes to the production of methane within landfills, but also is a significant contributor to GHG emissions associated with the production of the food, as well as the collection of food waste for diversion. On-site organics management solutions, such as Rocket Food Waste Composter, Food Cycler, BioHiTech and HomeBiogas are just a few examples of potential solutions that can be deployed in York Region based on specific community and infrastructure needs. It is recommended that the Region monitor these technologies as they evolve and when readily available consider piloting at community centers where food prep or community

gardens are present. In addition, the Region can leverage connections within business communities with these technologies.

Mixed Waste Processing

Description: Several communities across North America have opted to simplify waste disposal for residents by allowing residents to commingle all waste materials into a single container; garbage, recyclables and organic waste. The waste is delivered to a mixed waste processing (MWP) facility, often referred to as a "Dirty MRF". MWP facilities operate similarly to single-stream MRFs but have specialized equipment at the front-end to separate contaminants from recyclables. These facilities have been around for several years but have gained traction recently due to low participation and stagnant recycling rates in some North American cities.

Studies conducted at MWP facilities indicate they are typically able to capture a maximum of 30% of marketable recyclables from the waste entering the facilities. Given recent tightening of recyclable market quality requirements, many of the existing MWP facilities have encountered significant challenges. Even prior to the recent tightening of markets, several MWP facilities stalled or shut down. In Montgomery, Alabama, an MWP touted as a "first of its kind" in the country started operations in May 2014 with a capital investment of $35 million[27]. The 82,000 sq. ft. facility was designed to handle 225,000 tons per year and expected to recover 95% of recyclables using optical technology, series of discs, and manual sorters. The facility lasted less than 18 months shutting down in October 2015 citing commodity pricing issues.

In Ontario, residential recycling infrastructure is fairly developed in most communities which has limited the discussion around the use of MWP facilities; however, as GTA communities have seen a surge in the development of multi-residential buildings, which typically have significantly lower recovery rates compared to single-family buildings (typically half of the single-family recovery rate) while also having higher contamination rates has given momentum on the use of MWP to sort waste generated from these buildings. In 2015, Canada Fibers acquired the former Dongara Pellet Facility in Vaughan, Ontario to convert it into a MWP and test the applicability of MWP processing to recover recyclables from residential waste streams, including those source from multi-residential buildings. Initial testing in 2017 had shown positive results of possibly diverting 40% of inbound materials[28]; 5 to 6% of recyclables and 32 to 36% of organics/fines.

As Ontario moves to full producer responsibility, it is expected that producers will be required to meet material specific targets following the transition of the Blue Box. Industry will likely need to innovate and identify alternative avenues for capturing recyclables from sources typically with lower capture rates; multi-residential buildings. This presents an opportunity for industry and municipalities to collaboratively explore MWP options, as it is likely municipalities will still be responsible for the collection of the residual waste stream. Municipalities could potentially operate as a service provider to

producers and target the recovery of recyclable materials from residual waste streams increasing municipal diversion while also enabling producers to meet their targets.

Meeting Region Objectives:

- ✓ Increasing overall waste diversion – by allowing for additional capture of recyclables materials that typically would have been disposed or incinerated when placed in the residual waste stream.

Opportunity: MWP may be considered for waste streams that are heavily contaminated such as public spaces, multi-residential and industrial, commercial and institutional (IC&I) sources. As multi-residential buildings in York Region generate about 4,000 tonnes of waste annually, investing in an MWP facility is not recommended given the significant capital investment. However, York Region should consider potential partnerships with surrounding municipalities as they explore investing in MWP facilities. The City of Toronto has undertaken a study in 2019 to explore "testing technology and plan, build design of a Mixed Waste Processing facility with Organics Recovery"[29]. The Region can consider a strategic partnership with the City of Toronto or Peel Region, who has also explored MWP with Canada Fibers, by providing tonnages to support the business case for Toronto.

MRF Robotic & Artificial Intelligence Technology

Description: As current end market issues have significantly increased the difficultly in marketing materials, MRF operators are looking to new technologies to clean up their commodities. Artificial Intelligence (AI) and robotic technology have recently sprung forward as the technology of the future, allowing MRFs to move towards full automation. With fully automatic MRFs, sorting can occur for longer periods without having to retrain staff or risk being understaffed.

MRF robotics and AI technology is different from optical sorting technology, as it relies on a robotic arm to physically pick-up materials rather than using jets of air. Additionally, the sensors on the robotics can distinguish materials based on size, colour, and shape within changing conditions like a human eye, enabling the software to "learn" and adapt based on the materials it sees. This is a departure from the traditional optical sorter sensors that relies on a near-infrared (NIR) signature to identify the material.

Robotic technology has a smaller footprint compared to optical sorters, which require acceleration belts, compressors, and chutes at the end of the belts. Robotic equipment can be installed at existing manual sorter locations and can even use the same chutes as manual sorters. In the event the robotic technology is down, manual sorters can be reintroduced into sorting operations.

Currently, most of the major MRF equipment vendors provide robotics technology; SamurAI[30] supplied by Machinex, Bollegraaf RoBB[31] supplied by Van Dyk Recycling Solutions, ZenRobotics Fast Picker[32] supplied by ZenRobotics, and Max-AI[33] supplied by Bulk Handling Systems. Several MRFs across North America have recently installed

robotic technology; however, most are in the US and only one to-date is in Canada; Sani-Éco MRF in Granby, Quebec[34].

Meeting Region Objectives:

- ✓ Increasing cost savings – by allowing for longer operating times, it can reduce costs associated with manual labour.
- ✓ Increasing overall waste diversion – by effectively capturing recyclables from residual lines, and/or by improving sorting efficiency at quality control lines.

Opportunity: As MRF Robotic & A.I. Technology is still in its infancy, it will be important for York Region to monitor and track developments of this technology. Most of the equipment vendors indicate the efficiency of these robots to be about 60-70 picks per minute, while the average manual sorter can pick between 30 – 50 picks per minute. Given the relatively small increase in productivity, high investment cost and uncertainty regarding the role of municipalities as Ontario transitions to Individual Producer Responsibility (IPR), it is not recommended for the Region to invest in the technology without additional data collection.

Summary

The following table summarizes identified opportunities included in this report and recommends actions to consider that can be easily implemented, considered after further study or monitored over the longer term.

Technology/ Initiative	York Region Priorities	Implementation Cost	Action
New & Emerging Technologies and Initiatives - General			
Using Data to Maximize Diversion	• Reduced GHG emissions • Increased cost savings • Increased overall diversion	$$ Data tracking encompasses a broad number of studies, tools and systems. Costs are dependent on the number of studies to be conducted (waste audits, etc.), data tracking technology (RFID tags, scales on trucks, etc.) and data management systems (reporting software, etc.)	Implement Immediately • Focus on data collection at different waste sources (single-family houses, public spaces, multi-residential buildings, etc.) to better understand the composition and capture rates. Ensure obligated materials that are the responsibility of producers are not inadvertently flowing through municipal waste streams.
New & Emerging Technologies and Initiatives for Household Collection			
Cart-Based Collection	• Increased cost savings • Increased overall diversion	$$$ Switching to cart-based collection is capital intensive as new carts will be required for all households, with each cart costing around $80 - $120. Additionally, new collection trucks will need to be purchased or existing trucks retrofitted; however, retrofitting rear-loaded trucks would only allow for semi-automation of trucks which wouldn't allow the Region to fully realize the benefit of cart=based collection with full automation.	Consider • Undertake a study to assess the impacts of switching to a cart-based collection utilizing a utility-based fee model. Will require working closely with local municipal partners and collection service providers. • As the Blue Box program will be transitioning to producers, it will be critical for York Region to assess the impacts of the transition on the residual waste and green bin programs.

Technology/ Initiative	York Region Priorities	Implementation Cost	Action
Electric Trucks/Vehicles	• Reduced GHG emissions • Increased cost savings	$$$ Electric truck costs can range from $500K to $700K per truck.	Monitor • Review findings from US and other municipalities in a few years that have recently deployed electric trucks for collection.
Autonomous Collection Trucks	• Reduced GHG emissions • Increased cost savings	$$$ Limited information is available on the cost of autonomous collection trucks. As this technology is still in its infancy, it is assumed the cost would be significantly greater than regular collection trucks which cost $400K – $500K.	Monitor • Technology is still in its infancy and being trialed for long haul purposes. York Region should monitor these developments and assess potential impacts to transfer stations if the need arises.
Underground/Automated Waste Collection Systems	• Reduced GHG emissions • Increased cost savings	$$$ Several studies conducted in New York as well as Europe have indicated the investment cost for installing an automated waste collection system was approximately 30% - 60% more expensive than establishing a manual collection system.	Consider • Undertake a study to determine if underground/automated waste collection systems would be appropriate for the Langstaff Development. Incorporating this technology may serve as a testing point for future developments in York Region, as well as other municipalities.
New & Emerging Technologies and Initiatives for Public Space and Public Drop-Off Collection			
Public Space Green Bin Collection	• Reduced GHG emissions • Increased overall diversion • Decreased contamination of other waste	$ Costs are largely limited to the purchase and installation of bins. In-ground bins can cost around $3,000 per bin, but regular carts can cost around $100 to $300.	Implement Immediately • Low cost to implement and will align with existing green bin program.

Technology/ Initiative	York Region Priorities	Implementation Cost	Action
	streams		
Solar Compacting Garbage Bins	• Reduced GHG emissions • Increased cost savings • Decreased contamination of other waste streams	$$ Purchase and installation of bins can cost $7K - $13K per bin.	Consider • Undertake a study to identify appropriate technology and locations to deploy solar compacting bins. Can enhance underserviced areas while combating litter issues.
Collection of Construction, Renovation & Demolition Waste	• Increased overall diversion • Alignment with provincial and federal policies	$$ Cost for collection of CRD waste includes staffing and bins at depots, hauling costs and processing tip fees. Given the low value and challenges with sorting mixed CRD wastes, tip fees are typically high as well as cost of transportation.	Monitor • CRD materials have been identified by CCME to be targeted for future EPR regulations. Limited markets and sorting technology prevent further expansion of this program. Region to monitor developments as stakeholders enter into the market to sort or recycle additional CRD materials.
New & Emerging Technologies and Initiatives for Waste Sorting and Processing			
On-Site Organics Management	• Reduced GHG emissions • Increased cost savings • Increased overall diversion • Decreased contamination of other waste streams	$$ Cost for on-site organics management systems can range from small countertop units for household-use, around $400 -$1000 to small outdoor vessels for small community centers $20K - $40K.	Monitor • Conduct a broad study to evaluate existing technology and potential applications to address food and organic waste at municipal sites.
Mixed Waste Processing	• Increased overall diversion	$$$ Mixed waste processing requires significant capital investment and specialized	Monitor • York Region and its local municipal partners do not have

Technology/ Initiative	York Region Priorities	Implementation Cost	Action
		equipment to handle the complex mix of materials to be managed. Costs are typically greater than that of building a new MRF.	significant volumes to warrant the building of a MWP facility, especially given the existing EFW and proposed upgrades at the facility by Durham Region. York Region should actively participate in discussions with Durham Region, and other municipalities to support mutually beneficial investments and advancements in MWP.
MRF Robotic & Artificial Intelligence Technology	• Increased cost savings • Increased overall diversion	$$ The cost for each system including delivery and installation can range from $600K to $1 million.	Monitor • Technology was designed for MRFs, but as the Blue Box program transitions, the need for this technology may not be relevant for York Region.

[1] The Resource Productivity and Recovery Authority (RPRA) identifies municipal groupings based on population and population density. York Region belongs to Group 1 – Large Urban Municipalities.
[2] https://rpra.ca/wp-content/uploads/2017-Residential-Waste-Diversion.xlsx
[3] https://www.researchgate.net/profile/Bram_Van_Der_Heijde/publication/266097220_Big_Data_GIS_Analytics_Towards_Efficient_Waste_Management_in_Stockholm/links/5433af980cf22395f29e2768/Big-Data-GIS-Analytics-Towards-Efficient-Waste-Management-in-Stockholm.pdf
[4] http://www.applications.ene.gov.on.ca/ccap/products/CCAP_ENGLISH.pdf
[5] https://www.electrive.com/2019/02/20/first-fully-electric-volvo-trucks-delivered/
[6] https://www.volvogroup.com/en-en/news/2017/may/news-2561936.html
[7] https://www.markham.ca/wps/portal/home/business/planning/planning-documents-and-studies/studies/langstaff-master-plan-project
[8] http://www.utrc2.org/sites/default/files/pubs/pneumatic-waste-manhattan-report-Final_0.pdf
[9] https://www.toronto.ca/community-people/animals-pets/pets-in-the-city/green-bin-pilot-in-city-of-toronto-off-leash-dog-parks/
[10] https://www.theglobeandmail.com/canada/toronto/article-what-to-do-with-all-that-dog-poop-ontario-cities-come-up-with/
[11] https://vancouver.ca/home-property-development/dog-waste-collection.aspx
[12] http://bigbelly.com/
[13] https://www.toronto.ca/311/knowledgebase/kb/docs/articles/solid-waste-management-services/transfer-disposal-and-operations/prohibited-waste.html
[14] https://guelph.ca/living/garbage-and-recycling/waste-reduction/construction-and-demolition-waste/
[15] https://ovwrc.com/construction-demolition-site/
[16] https://www.kawarthalakes.ca/en/living-here/diversion-programs.aspx
[17] https://www.mykawartha.com/news-story/9444517-kawartha-lakes-council-extends-pilot-program-to-divert-construction-waste-from-landfill/
[18] http://tryrecycling.com/
[19] http://www.countrywiderecycling.ca/construction-material-recycling/
[20] https://www.slideshare.net/TorontoPCU/city-of-toronto-long-term-waste-management-strategy-april-7-2016-waste-diversion-for-businesses-and-home-renovators-webinar-slides
[21] https://www.peelregion.ca/planning/officialplan/pdfs/Discussion_Paper_-_Peel_Integrated_Waste_Management_Feb.2009.pdf
[22] https://lovefoodhatewaste.ca/about/food-waste/
[23] https://www.emerson.com/en-ca/commercial-residential/grind2energy-food-waste-solution/home
[24] https://www.tidyplanet.co.uk/our-products/the-rocket/
[25] https://files.ontario.ca/food_and_organic_waste_policy_statement.pdf
[26] https://files.ontario.ca/food_and_organic_waste_framework.pdf
[27] http://industrialpartners.com/montgomery-alabama-commercial-real-estate/infinitus-renewable-energy-park-at-montgomery/
[28] https://resourcerecoverypartnership.ca/wp-content/uploads/2018/11/ClosingTheLoop_MZabeneh_June2018.pdf
[29] https://www.toronto.ca/legdocs/mmis/2019/bu/bgrd/backgroundfile-123937.pdf
[30] https://www.machinexrecycling.com/samurai/
[31] https://vdrs.com/bollegraaf/
[32] https://zenrobotics.com/
[33] https://www.max-ai.com/
[34] https://www.recyclingproductnews.com/article/31196/editor-in-the-field-from-the-factory-floor-to-the-mrf-in-quebec