Informing Municipal Planning: Lessons Learned from the Development of a By-Product Waste Exchange in Toronto, Ontario.

by

Tessa Wilson

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The Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Municipal Solid Waste Management (MSWM) is becoming an increasing challenge for municipal authorities due to global increases in waste quantities. Other challenges include; changes in waste composition and increasing concern for the environment. As cities continue to grow, so too will the waste. The management of waste therefore becomes critical to municipal planning. Health and sanitation, aesthetics, minimization of pollution and the monitoring of critical resources are just some of the reasons municipalities must manage and control solid waste. Using the Toronto Pearson Eco Business Zone as a case study, this thesis explores how waste (by-product) exchanges might inform municipal planning and how waste exchanges could advise planners and academics in managing growing amounts of municipal waste. The Toronto Pearson Eco Business Zone is a developing Eco Industrial Park which utilizes theories and concepts of ecology and resource recovery to reduce waste. Utilizing a qualitative research approach, data was obtained from businesses throughout the Park to develop a waste exchange database.

The results of this study suggest that the application of concepts underlying Eco Industrial Parks such as a by-product exchange program can assist to drive resource recovery and sustainable waste management practices. However, users of the exchange are highly uneducated or unaware of the links between waste and resources. This was made evident by the fact that companies were more inclined to continue the practice of revenue recycling over the sustainable approach as offered by the exchange. This conclusion suggests that although a waste exchange can help to drive resource recovery, increased education and awareness through mandatory regulations could help to drive resource recovery even further. For the greater success of waste management in Canada, the Government should take action to regulate the planning and organization of waste exchanges in industrial and surrounding areas. The Pearson Eco-Business by-product exchange suggests that cities should not be planned without consideration of solid waste and resource recovery therefore suggesting that concepts related to Eco-Industrial parks should be applied to all municipal and city planning moving forward.

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1.0 Introduction

Municipal Solid Waste Management (MSWM) is becoming an increasing challenge for municipal authorities due to global increases in waste quantities. Other challenges include; changes in waste composition and increasing concern for the environment. As cities continue to grow, so too will the waste. The management of waste therefore becomes critical to municipal planning. Health and sanitation, aesthetics, minimization of pollution and the monitoring of critical resources are just some of the reasons municipalities must manage and control solid waste. One aspect of waste management related to global resources is the concept of the extraction of useful material or energy from a waste stream, better known as resource recovery (Parker, 2010; McGurty, 2003; Chertow, 2000). Nowhere is resource recovery better utilized than in Eco Industrial Parks (EIPs). EIPs are defined as industrial areas in which businesses cooperate to reduce waste and pollution by sharing resources and recycling waste within the park borders (Derochers, 2001; van Leeuwen, 2003). Kalundborg Eco Industrial Park in Denmark was one of the first parks created during the 1970's and since; many similar parks and programs have been established in both the developed and developing world including several Canadian examples; *Calgary Materials Exchange, Ontario Waste Materials Exchange, Recycling Council of BC Materials Exchange and the Dalhousie/Burnside Eco-Industrial Park.* One recent EIP development is the Toronto Pearson Eco Industrial Park in Toronto, Canada. The Toronto Pearson EIP was created roughly a decade ago by a partnership between the Greater Toronto Airports Authority (GTAA) and the Toronto and Region Conservation Authority (TRCA). The partnership is known as, *Partners in Project Green* and they have named the EIP the *Pearson Eco-Business Zone.* The project's vision is to work with local businesses in transforming the lands surrounding Toronto Pearson into an internationally recognized eco-business zone the goal being to have the companies recognized globally as the greenest in their sectors, and have the

area itself become a place where progressive green-tech companies look to locate. Parks such as the Toronto Pearson are becoming increasingly popular due to their ability to reduce the overall waste of cities and contribute to city-wide sustainability and waste management policies. However, there is a lack of understanding regarding how Eco Industrial Parks and related concepts may inform or influence municipal planning, more specifically, Municipal Solid Waste Planning (MSWP). Therefore, further research on EIPs and their waste recovery systems will help to contribute to waste policies and assist in more efficient city-wide waste planning. The purpose of this study is to determine if aspects of functioning EIPs can be applied to large-scale city planning to assist in reducing waste and contribute to resource reduction and recovery. The study is guided by four major research questions:

1. What are the past experiences and successes of previous waste exchanges in Ontario, the world?
2. What is the desire or need for the creation and success of a working waste exchange?
3. What is the connection or link between waste and resources?
4. How can waste exchanges inform or influence municipal planning?

In order to conduct this research and answer the above questions, the Toronto Pearson Eco Industrial Park has been selected as a case study. This study will explore the true feasibility of creating a working and successful waste exchange within the Pearson Eco-Business Zone and determine how waste exchanges can be used to inform municipal planning, specifically Municipal Solid Waste Planning. By developing a working exchange within a Canadian EIP, it is anticipated that an understanding of the importance of waste management to municipal planners and environmentalists will be determined and that the findings will help to inform large-scale city planning throughout Canada, as well as a professional and academic community involved with waste and resource planning.

2.0 Review and Application of Literature

2.1 Waste Management

Due to the wide range of features that "Waste Management" encompasses, for the purpose of this study, the focus of the Waste Management literature surrounds waste management mainly as it relates to industrial parks. However, a brief introduction to the general aspects of Waste Management and its development through history is explained below.

2.2 Waste Management Systems

To begin, Shekdar (2009) explains that a Solid Waste Management system (SWM) can be thought of as a large materials handling system that is distributed over an entire city for collection of solid waste and subsequent transport to the outskirts for processing and disposal. Figure 1 below graphically depicts the typical components of a Solid Waste Management system. SWM is becoming increasingly important for a variety of reasons, including the concentration of the population in municipal areas, legal interventions, and the emergence of newer technologies and rising public awareness of the importance of hygiene and sanitation. Shekdar explains that "waste" is typically defined as "Solid Waste" which includes food waste from residential sources, plastics and papers from institutional sources and landscaping materials from municipal sources. Geng et al. (2007, p. 141) recognizes the incredible importance of EIPs and waste management when they state: "proper management of solid waste is a major challenge for industrial parks due to the large quantity of wastes and variability of wastes that are expelled from these developments." Furthermore they argue that solid waste management has become very crucial to the industrial park managers such that an approach requires industrial park managers to assess the overall use of resources, and to seek waste reduction, reuse and recycling opportunities both at the individual and company level. (Geng et al. 2007; Hunga, 2007).

Figure 1: Depiction of a typical Waste Management System (Shekdar, 2009).

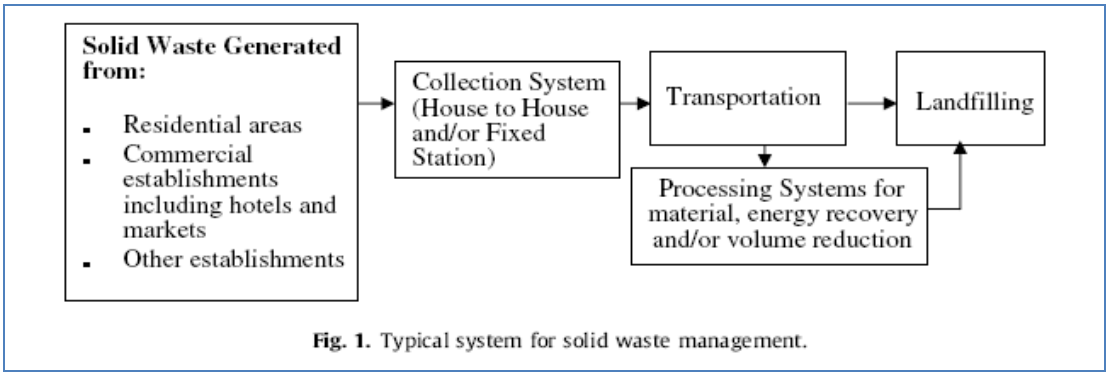


Fig. 1. Typical system for solid waste management.

2.3 Historical Context of Municipal Solid Waste Management (MSWM)

Global Municipal Solid Waste Management (MSWM) historically began as a reaction to poor health and sanitation in cities. As early as 2000 BC, the development of dense, urbanized town and cities created a need for organized solid waste management. Drivers such as aesthetics and concerns for public health laid the foundation for the establishment of waste management systems (Louis, 2004; Vergara and Tchobanoglous, 2012). The industrial revolution brought masses of people to cities like never before, resulting in health epidemics related to poor urban sanitation. Pressure from public for changes to the conditions of filth and disease resulted in the establishment of municipal sanitation services. Water and sewage were addressed with elevated priority, although refuse continued to pose problems. This pressure resulted in increased institutional attention and the establishments of municipal service for waste management. Waste management at the end of the nineteenth and early twentieth centuries consisted primarily of removal of the material from one location to another (Louis, 2004). This process of removing

waste from cities resulted in the creation of local "dumps" or landfills which are still widely used today in MSWM.

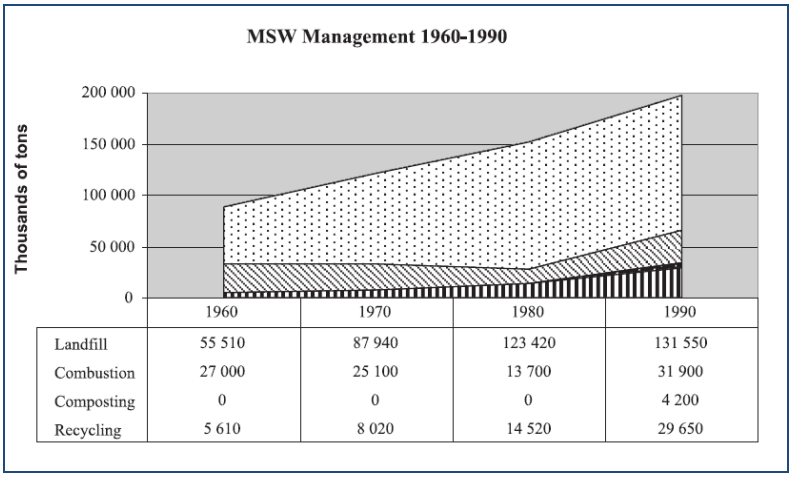
The period between the 1920s and 1960s saw tremendous advances in technology resulting in new industries such as the automobile industry as well as chemical and electrical industries. In addition to growth in technology and innovation, there was also a major population growth globally expanding the physical size of cities. Accompanying these technological advancements and population growth was the dramatic increase in the amount municipal waste generated (Louis, 2004; Vergara and Tchobanoglous, 2012). In addition, changes to the waste stream occurred resulting in more paper, plastics, and toxic chemicals than ever seen before. Municipal services between these periods had to deal with the increased consumption resulting in the creation of sanitary landfilling. Sanitary landfilling is generally described as the establishment of designated sites for a municipality's refuse controlled by local government. Sanitary landfilling remained the main method of waste disposal during this period of time. Recycling and the recovery of wastes can also be contributed to this time period due to the shortages of resources being used for War Production. For example, between 1941 and 1945 a national recycling effort in America was promoted through the War Production Board (WPB). Under this board the nation was urged to recycle paper, glass, metals and systems for recycling paper and scrap metal were instituted. However, at the end of war the need for metal and paper was diminished and recycling was de-emphasized and declined in popularity again until the 1970's. Governments also became increasingly involved with the regulation and financing of municipal waste management services with the passing of the 1965 Solid Waste Disposal Act. This Act brought increased federal attention to issues surrounding solid waste. The intents of the Act included: facilitate the implementation of environmentally sound solid waste management

and resource recovery systems; provide technical and financial assistance to states, local governments and interstate agencies in the planning and development of these systems; and, Initiate and accelerate a national research program to develop these systems and provide guidelines and training for their effective implementation (Louis, 2004).

During the late 1960s and 1970s there was a shift in the way cities were focusing and managing their municipal solid waste. The Resource Conservation Act, which was passed in the US in 1976, dramatically altered the global focus of solid waste management from recycling to recovery. The Recovery Act was definitive legislation which helped to establish stricter standards for sanitary landfills and prohibited the open dumping of wastes (Vergara and Tchobanoglous, 2012). The Act also resulted in the closing of many open dumps as well as a decline in the number of active landfills in the US as it clearly defined where waste treatment facilities may be built and the environmental standards that they must comply to. In addition, cities realized that it was more expensive to keep a landfill that met environmental standards running and therefore, regions invested in larger landfills that served multiple municipalities. This change resulted in regional-scale waste management (Vergara and Tchobanoglous, 2012). Figure 2 demonstrates Municipal Solid Waste between 1960 and 1990 in the US. This graph shows influences of shifting waste management focus on recovery as both recycling and composting increased dramatically between the periods when the Recovery Act of 1976 was enacted to 1990 (Louis, 2004). It is important to note that although the legislation discussed focuses on the passing of US laws only, similar focus on waste management techniques was occurring globally. Specifically, Paehlke (2009) outlines that environmental conservation in the US and Europe was generally ahead of Canadian concern for the conservation of resources. This was likely due to the extensive human settlement in the US which demonstrated the negative

impacts on the environment (p. 3). However, it is argued that Canadians became aware of pollution and resource limits with the passing of the National Environmental Policy Act (NEPA) and other resource and conservation acts during the 1960s and 1970s (Paehlke, 2009). Generally speaking, global concerns over resource limits and the affects of pollution from wastes became a significant driver in the management of municipal wastes.

Figure 2: Municipal Solid Waste Management between 1960 and 1990 (Paehlke, 2009)



	1960	1970	1980	1990
Landfill	55 510	87 940	123 420	131 550
Combustion	27 000	25 100	13 700	31 900
Composting	0	0	0	4 200
Recycling	5 610	8 020	14 520	29 650

2.4 Waste Management Systems and Municipal Planning

Chang et al. (2011) explains that Municipal Solid Waste Management (MSWM) fits within a complex system of systems in which subsystems such as landfills, incinerators, anaerobic digestion units, composting facilities and recycling centres are linked with each other through processed waste streams internally providing varying functionality and performance (p. 1450). It is suggested that the interrelated components of a solid waste management system must be considered in integration in order to arrive at an optimal waste management plan (Sirvastava and Nema, 2011.) This 'systems approach' is often applied as the planning framework for

designing and planning municipal solid waste systems as it results in forward-looking, cost-effective, risk-informed and environmentally mindful decisions regarding sustainable solid waste management (Chang et al. 2001; Sirvastava and Nema, 2011; Ljunggren, 1998). SWM systems can be a closed system in which the SWM network can be sustained internally with no transboundary movement or can be an open system needing materials and energy from outside social and economic channels. Functionality and performance make part of the SWM system exhibit interactions between various technical (i.e. processing facilities) and nontechnical aspects (i.e. environmental law), both of which may influence the source and shipping of waste streams to some extent (Chang et al. 2011). Furthermore, this type of systems analysis has been applied to many waste management organizations since the 1960's to assist in developing long-term municipal solid waste (MSW) management plans and short-term waste management operational strategies with respect to various socioeconomic and environmental objectives. Within the last few decades, the development of SWM technologies has focused on a range of waste management aspects including: the planning and maintaining environmental quality, renewable energy recovery, and preservation of natural ecosystems (Chang et al., 2011). Ljunggren (1998) argues that due to complexities of planning for solid waste, computer models are now utilized for strategic planning. These models assist in evaluating several aspects of Solid Waste Management including economic and environmental points of view such as: waste treatment technologies and waste policies, potential for materials recycling and energy production, reduced waste generation and treatments of specific materials. Pires et al. (2010) argues that all technical and non-technical aspects of a solid waste management (SWM) system should be analyzed as a whole as they are inter-related with one another and that developments in one area frequently affect practices or activities in another area. The authors also argue that a 'systems analysis' technique have been

applied to handle MSW over the last few decades and explains that a system can be a set of related components or sub-systems, which interact with each other in some way. Further, with this definition, a MSW management system fits the concept in which the technical aspects like landfill, incineration, anaerobic digestion, composting and collection are sub-systems linked with one another through processed waste streams internally and municipalities through managed truck fleets externally. To summarize, municipal solid waste planning is done with a systems approach encompassing numerous aspects of the waste management structure and ensuring a diverse planning solution.

2.5 Drivers for Municipal Solid Waste Management and Planning

MSW is often influenced by four distinct drivers including legal drivers (laws and regulations), technological drivers (available technologies), regional and international drivers (solid waste flow as recyclable resources and pollution); and socio-economic drivers (population trends and public awareness) (Contreras et al., 2010). Legal drivers are identified as the "obligations of municipalities" for the collection, treatment and disposal of solid waste and most recently have been developed as a response to the increasing amount of solid waste generated by cities. Technology is described as an important driver in shaping early MSW as industrialization brought people to urban centers creating mass amounts of waste affecting air, water and soil. In response SWMS were developed to assist in treating and disposing of the waste. Further, the international trade of recycled materials has affected solid waste management as the outflow of this material has repercussions for the local recycling or incineration plants. SWM is largely affected by Socio-Economic drivers including rapid increases in urban populations as well as increased consumption rates both of which have created increases in amounts of waste being generated. Authors Zhang et al. (2010) explain that a sound planning practice regarding

economic development, environmental impact, resources conservation and even political consideration is essential for planning MSW. Specifically, Vergara and Tchobanoglous (2012) suggest four major drivers of waste management; public health, environmental protection, resource recovery and climate change. Public health is a large driver in cities where lack of infrastructure for waste management exists. For example, in places like Haiti or China, waste is commonly dumped in an uncontrolled manner causing in some cases, the spread of disease. In other cases the burning of wastes can emit toxic substances which can directly harm people. Environmental protection drives waste management policies usually through enacted legislation. For example, in the Island nation of Mauritius the construction of a landfill was the direct reflection of the need to protect ocean and coral reefs. In instances where resources are scarce materials are recovered, repaired or reused suggesting that resource recovery is usually determined through economic signals and is also a major driver in waste management. Recently, climate change has also become a large driver in waste management in both industrial and industrializing countries. Threats of greenhouse gas emissions from landfills - which are the sources of these gases within waste management systems, have resulted in policies, legislation and the construction of new sanitary landfills to manage the emissions.

2.6 Waste Management and Sustainability

The concept of "Sustainability" was first derived from the definition set forth by the *Brundtland Commission* in 1987 who defined the term sustainable development as, "development which meets the needs of the present, without compromising the ability of future generations to meet their own needs' (Basiago, 1995, p. 109). Spawning from this definition, the term sustainability is now used widely in biology, economics, sociology, urban planning, ethics and other domains and is a philosophy in which principles of equity, global environmentalism and biodiversity must guide decision-making (Basiago, 1990). Glavic and Lukman (2007) argue

that clear definitions of sustainable development are critical as the number of related terms continues to increase and also recognizing problem with clarity and ambiguity. Not only is an understanding of the term sustainability essential to this study due to the variance of its use in research and academia today, but also critical because waste management plays a large role in sustainability practices of many organizations and institutions today. For example, Shekdar (2009) explains that solid waste management systems (SWMS) in recent times have been oriented to focus on sustainability mainly through the incorporation of 3R (reduce, reuse and recycle) technologies and also argues that SWM in keeping with global trends are being oriented to concentrate on sustainability issues. Likewise Hung et al. (2006) explains that that in the 1970s, the goals of MSWM were simple and narrow, such as optimizing waste collection routes for vehicles or locating appropriate transfer stations but by 1990 numerous factors were being considered in MSWM models including; environmental (air emission, water pollution) and technological (the maturity of technology). Focusing on an international study of New Zealand, Boyle (2000) explains how the waste management industry is undergoing a great deal of change and explains that changes in legislation and increasing scrutiny of solid, liquid, emission and hazardous waste management and pollution prevention practices has resulted in increasing pressure on regional and local governments to manage waste and prevent pollution more effectively. Rathi (2005) argues rapid growth of population and industrialization is degrading the urban environment, placing stress natural resources and undermining equitable and sustainable development. These global changes are forcing cities to focus on promoting sustainable waste management practices. Geng et al. (2007) and Roberts (2004) express that integrated solid waste management can be used to develop a sustainable solid waste management system as this model assesses the overall use of resources in the system and seeks waste reduction opportunities

through reuse and recycling. In general, it is clear that waste management in recent decades has had to develop to incorporate sustainability concepts so as to deal with negative effects of growth and resource depletion.

2.6.1 Sustainable Waste Management

Highlighted in the brief history of MSWM, it is argued that the traditional view of waste is that of a linear process. Simply, waste is a resource that is consumed. However, modern generations such as those that emerged in the 1970s, have a more sustainable view of waste encapsulating it as part of a resource cycle (Powrie and Dacombe, 2006). This cycle includes extraction of resources from the environment and then eventual return of them to the environment. The waste is therefore viewed as an input for other processes. Just as recycling was developed during World War II due to a lack of resources such as metal and paper, it is clear that when necessary, humans recognize the link between utilizing what was previously regarded as waste instead as a resource. Similarly, it is argued that waste recovery is often driven by economic signals. In instances where resources are scarce for example, materials are recovered, repaired or rather than be discarded (Vergara and Tchobanoglous, 2012). For example, it is argued that resource recovery is a critical driver of waste management in "cash-poor" cities throughout the developing world and very important to some economies such as India and China. Countries such as these depend on the secondary materials which remain the main cause of many informal recycling systems. Taking these themes of resource management into perspective, it is argued that modern waste management advocates more for avoidance and minimization of waste production through recycling and recovery than previous generations. However, even cities and regions with the most successful source separation mandates still show significant quantities of residual waste (Veils et al., 2010). Parker (2010) argues that so far, most efforts in resource

efficiency and waste management have been directed at the reprocessing or recycling of waste, but that recent legislation is advocating for actions higher in the waste hierarchy. For example, Figure 3 below demonstrates the waste management hierarchy where most focus in the last few decades has been on the recycle and recovery levels. Parker, however suggests, that to move up in the hierarchy, changes must be made at a manufacturer level with closed-loop manufacturing systems that stress the importance of cost-effective product recovery. It is further argued that waste management can be practiced in a sustainable manner thus avoiding excess quantities of residual waste. Figure 4 below highlights Powries and Dacombes (2006) "Pillars of Sustainable Management" of which includes requirements and opportunities for reducing waste and practicing sustainable waste management. These terms commonly promote the ideals of using waste as a resource through the promotion of exchanging waste and the development of closed-loop systems.

Figure 3: The Waste Management Hierarchy (Parker, 2010).

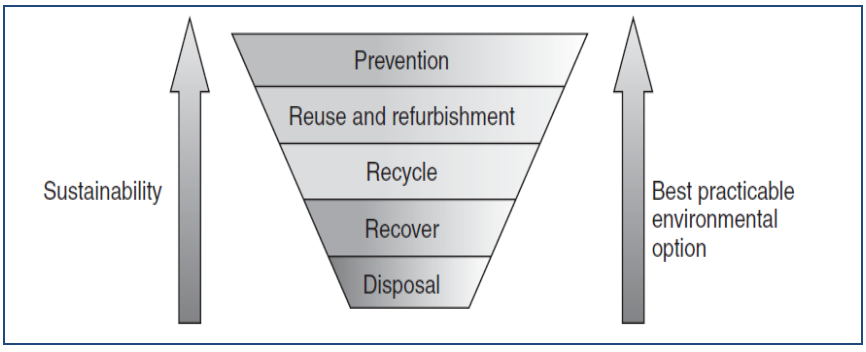
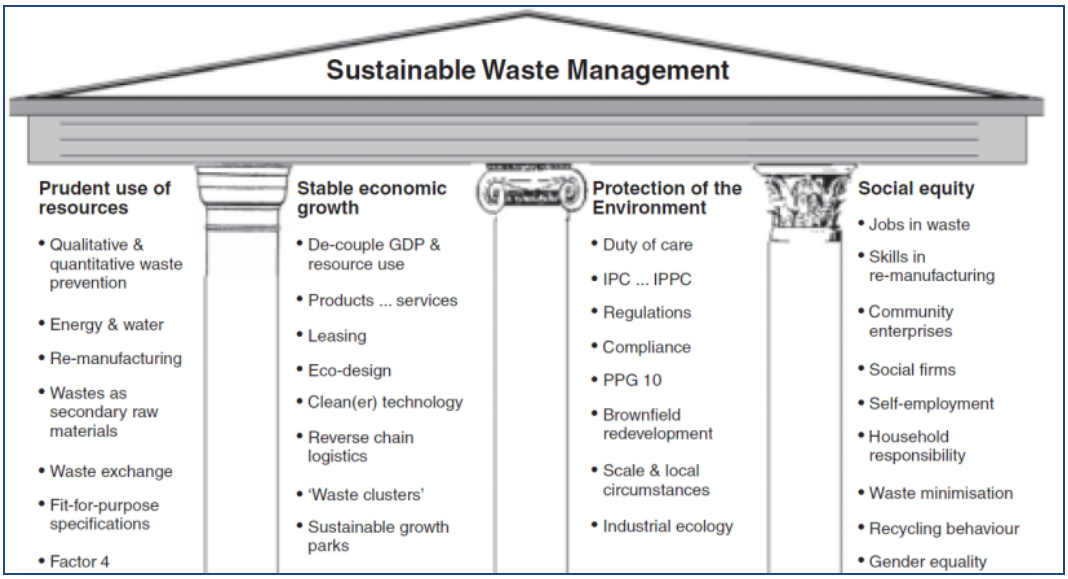


Figure 4: The Pillars of Sustainable Waste Management (Powries and Dacombes, 2006).



2.6.2 Waste Diversion

Diversion in its basic definition is, "the act or instance of diverting from a course, activity or use" (Websters, 2011). According to Waste Diversion Ontario (2011) waste diversion is when waste is diverted away from the landfill to either some sort of recycling or composting program. Waste Diversion Ontario is just one example of a governmental organization created to assist with diversion throughout Canada. Senneh argues that the solution to waste management is not merely technical, but also organizational and suggests there is a great need to move away from the disposal-centric approach toward the recovery-centric approach of waste management (2010, p. 463). Senneh further argues that this paradigm shift requires some level of public participation by regulating and monitoring waste collection and disposal (p. 464). Likewise, Dawson et al. (2010) argues that throughout Europe waste has been recognized as a major environmental problem and legislative measures have been put in place to improve the sustainable management of waste. One of these measures includes a landfill directive which specified that by 2010

member states must reduce the amount of biodegradable municipal waste that is land-filled, and by 2020 landfill allowances will amount to only 35% of the quantity of the waste which was land-filled in 1995 (Dawson, 2010, p. 63). Moreover, the country of Wales introduced a waste strategy in 2002 which includes specific instructions regarding recycling and composting rates. Dawson argues that these diversion strategies and mandates have forced local governments to expedite their recycling and recovery policies with increased emphasis on local authorities to invest in long-term solutions by securing suitable markets for recycled materials (p. 70). Equally Young et al. (2010) conducted a study on Taiwan waste practices and noted that to assist the countries goal of reaching a zero waste policy many regulatory amendments on waste diversion were enacted. For instance, small targets have been set for 2005, 2007, 2011, and 2020 for both the municipal solid waste (MSW) and industrial waste to reach the goal of zero waste (Young, 2010, p. 237). Some of the major programs introduced by the mandates include; the establishment of a waste recycling program, a green procurement program, and promotion of public awareness. Since the implementation of the zero waste policy started in 2003, the volume of MSW for landfill and incineration has declined dramatically and the recycling of MSW quantity in 2007 was 37%, which is much higher than the goal of 25% (Young, 2010, p. 236.)

2.6.4 Waste Procurement

Procurement in its basic definition is, "the acquisition of goods and or services" and is a concept that is very closely intertwined with waste management sustainability practices (Merriam-Webster, 2011). For example, according to authors Ho et al. (2010) green procurement stems from pollution prevention principles and activities. Also known as green or environmental purchasing, green procurement compares price, technology, quality and the environmental impact of the product, service or contract (p. 24). Moreover, as noted by Ho et al. Green procurement practices can be utilized within waste management systems. For example, Ho et al.

explains that China, a country which has experienced rapid economic growth over the last several decades has developed a waste management plan that incorporates a green purchasing framework (2010, p. 24). Thomson and Jackson (2007) discuss how the UK's commitment to sustainable development has resulted in the establishment of a framework for green and sustainable procurement. This framework gives direction and guidance to government officials on the purchase and use of both products and services which are produced, offered and usable in a sustainable manner. Japan is the leading country in green public procurement and has developed eco-labelling, purchasing Guidelines, product lists, economic instruments, a mandatory reporting system, lifecycle analysis information and a public awareness program (Thomson and Jackson, 2007). The Japanese Government also enacted a *Green Purchasing Law* in May 2000, which states that all institutions are obligated to buy designated green purchase items from 200 products in 18 categories which include things such as; copy/printing paper products, stationery and office supplies (Ho, 2010, p. 30). In addition to purchasing green products, companies are to control waste through the reuse and recycling of materials (Ho, p. 30). This last point is of particular importance to this study as the focus will be to enhance the ability and ease of companies to recycle and reuse products within the Toronto Pearson Business Zone. On this point, author Michelson (2009) describes Green Procurement as, ‘‘the approach by which Public Authorities integrate environmental criteria into all stages of their procurement process, thus encouraging the spread of environmental technologies and the development of environmentally sound products, by seeking and choosing outcomes and solutions that have the least possible impact on the environment throughout their whole life cycle.’’ (p. 160). This particular definition is of significance because it highlights the holistic nature of the description and suggests that green procurement often involves the waste management aspect of

procurement. Moreover, Palmujoki (2010) outlines several green procurement contracts throughout the European Union one of which states, "All solid waste from the supplier's or its sub-contractor's facilities shall be sorted for recycling, composting or disposal" (p. 258). Similarily, Ho outlines one requirement of a green procurement mandate in Hong Kong which requires companies to control waste through environmentally responsible purchasing as well as the reuse or recycling of materials (p. 30). In general these points highlight the basic understanding of green procurement and have also sketched the general concept of waste procurement.

In April of 2006, the Canadian Federal Government implemented the Policy on Green Procurement. The policy strives to enable government to procure, operate and dispose of its assets in a manner that protects the environment and supports sustainable development objectives (Public Works, 2012). This policy applies to the procurement of goods, services and construction across all stages of the procurement process, from planning and acquisition through use, maintenance and disposal. The policy is intended to make the government a global leader in integrating environmental considerations into all aspects of our procurement system. The policy looks at Green procurement within the context of achieving value for money and considers many factors such as cost, performance, availability, quality and environmental performance. The Green procurement policy also requires an understanding of the environmental aspects and potential impacts and costs, associated with the life cycle assessment of goods and services being acquired (Public Works and Government Services Canada, 2012)

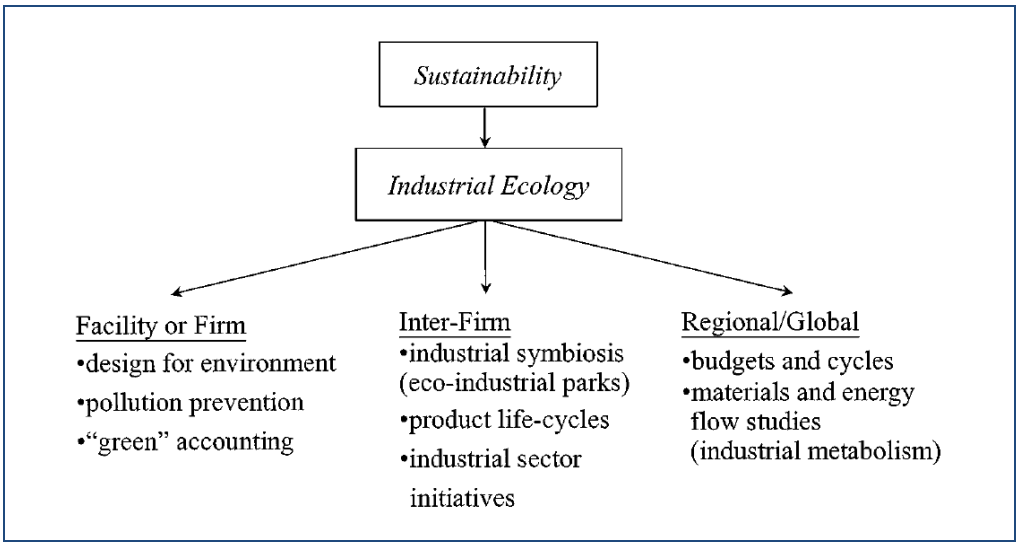
2.7 Ecology, Industrial Ecology and Industrial Symbiosis

To understand waste in the context of a resource cycle, concepts underlying ecology must be discussed. Wallner (1999) suggests that complex systems are found both in nature and in anthropogenic organisms. It is argued that systems can be complex such as of a tropical

rainforest or a large city. Within complex systems such as cities for example, there are subsystems such as industrial subsystems. Wallner suggests that these industrial subsystems can be developed towards sustainable organisms called *Industrial Ecology Systems* which use natural ecosystems as a guiding framework. Wallner compares a biological cell system to a business system similar to that of an Eco Industrial Park and expresses that EIPs are often modeled after ecological systems. As this study focuses on industrial wastes and the development of a waste exchange within an Eco Industrial Park the concept of Industrial ecology which is derived from concepts of ecology is important to highlight. The Eco-efficiency Centre (2010) defines Industrial ecology "as an interdisciplinary framework for designing and operating industrial systems as living systems interdependent with natural systems. It seeks to balance environmental and economic performance within an emerging understanding of local and global ecological constraints. Hoffman (2003) suggests that Industrial Ecology is a framework which challenges scholars and practitioners to think beyond a fragmented view of environmental problems and solutions and in its place focus on the holistic industrial system. Hoffman argues that Industrial ecology's central unit of analysis are industrial organizations within systems of facilities, regions, industries, and economies whose goals are to reduce environmental burdens through system-wide changes. Overall, the focus of analysis is the "ecology" of the industrial enterprise which includes the interconnected processes of raw material extraction, the production of goods, the use of those goods, and the management of the resulting wastes. Ehrenfeld (1997) and Cote and Hall (1995) describe the concept of Industrial Ecology (IE) as one emerging in the evolution of environmental management paradigms and derives from interests in integrating notions of sustainability into environmental economic systems. Figure 5 below demonstrates the aspects of Industrial Ecology as they relate to Sustainability and Industry. Erkman (1997) states three key

elements that make up the definition of Industrial Ecology and include; (1) it is a systemic, comprehensive, integrated view of all the components of the industrial economy and their relations with the biosphere, (2) It emphasizes the biophysical substratum of human activities, and (3) it considers technological dynamics. Hewes (2008) argues that a central element of industrial ecology is the concept of closed loop systems, where energy and waste materials are continuously recycled between geographically proximate firms – a process defined as industrial symbiosis (IS). Hewes's definition leads to the concept of Industrial Symbiosis generally explained by Derochers (2001; 2008) as an exchange between firms in which by-products of one industry become valuable inputs of another. Industrial symbiosis is derived from the premise of ecology in which living organisms consume each other's wastes. Industrial Symbiosis states that industrial economies should mimic the cycling of materials in ecosystems throughout the processes of raw-material extraction, manufacturing, product use, and waste disposal (Derochers, 2001; 2008). Haskins (2007) offers an abstract definition for Industrial Symbiosis: the latest in a stream of biological metaphors being used in IE (Industrial Ecology), business strategy, economics, and other fields. Following terms such as "industrial metabolism," "closed industrial ecosystem," and even "industrial ecology" itself, these metaphors connect the reader with a mental visualization of a network of interconnected actors exchanging matter and energy, without the creation of waste products or damage to the Earth's natural state" (p.318). These two definitions and their related concepts provide a base point for understanding that concepts of ecology and ecosystems can be applied to waste management.

Figure 5: The Levels of Industrial Ecology (Chertow, 2000)



2.8 Industrial Sustainability

Industrial Sustainability which is defined by Paramanathan (2004, p. 526) as; 'conceptualisation, design and manufacture of goods and services that meet the needs of the present generation while not diminishing economic, social and environmental opportunity in the long term." Similarly, sustainable production defined by Glavic and Lukman is "creating goods by using processes and systems that are non-polluting, that conserve energy and natural resources in economically viable, safe and healthy way for employees, communities, and consumers and are socially and creatively rewarding for all stakeholders for the short- and long-term future" (2007, p. 1883). Likewise Damjan and Glavic (2005) further argue that definitions of sustainability are often based upon a *triple bottom line* concept that covers three aspects including *environmental performance, societal responsibility* and *economic contribution*. These authors argue that organizations recognize and monitor these three aspects using sustainability indicators, which provide information on how the firm contributes to sustainable development

and explains that indicators are used to translate sustainability issues into quantifiable measures. This literature critically notes that sustainability embraces numerous characteristics and suggests that sustainability and industry are closely related and intertwined concepts.

2.9 Industrial Waste

This study focuses primarily on waste which is sourced from industrial units. An understanding of waste as it specifically applies to industrial sources is therefore fundamental to comprehend.

Industrial waste refers to all wastes produced by industrial operations or derived from manufacturing processes and can encompass food wastes, rubbish, ashes, construction and demolition wastes, special wastes and hazardous wastes (Caseras, et al. 2005; Chertow, 2005). Industries have traditionally managed their waste products by discharging them into the environment without previous treatment – a practice that resulted in an increase of pollution and produced a negative environmental impact (Caseras et al. 2005). However, the requirement for environmental quality resulted in a change of the whole concept of pollution control better known as Industrial Ecology practiced throughout many in Eco Industrial Parks. Using a case study analysis of an industrial park in Granada Spain the authors identified that many organizations within the industrial park did not practice proper waste management which they explain as one "that takes into account activities without negative environmental impact as: minimization, reuse, recycling, valorization and elimination in sanitary landfill" (2005, p. 1080.)

An important concept related to industrial waste and EIPs is the concept of a By-Product Synergy. The principle underlying by-product synergy is that one industry's waste stream can be used by another as a primary resource. This is a straightforward idea, but one that has impacts on reducing waste volumes being supplied from industrial sources. The resources in a synergy can

then be exchanged, sold, or passed free of charge between sites thus creating a by-product synergy (Eco Efficiency Centre, 2010).

2.10 Eco Industrial Parks

The definitions of Ecology, Industrial Ecology (IE) and Industrial Symbiosis (IS) provide a backdrop for the model of an Eco Industrial Park (EIP) and the relationship to environmental ecology. Leeuwen (2003) further explains that designing eco-industrial parks is a concrete application of industrial ecology and uses the Kalundborg EIP in Denmark to illustrate that symbioses (exchanges of resources and energy flows) between the companies has been attained. Kalundborg leads as a benchmark of eco-parks and is one of the most frequently used examples of an EIP because it was among the first of its kind in modern times (Leeuwen, 2003). Kalundborg EIP evolved as a series of independent, bilateral agreements beginning in the 1970s within a pre-existing industrial park with no existence of a grand plan and no government subsidy (Derochers, 2001).

Kalundborg, a small town along the coast of Denmark is a complex web of waste and energy exchanges which includes a power plant, a refinery, a fish farm, a biotechnical plant and a wallboard maker. Both the initial and current symbiotic exchange of waste materials is depicted in Figures 6 and 7. Kalundborg Symbiosis occurred as a result of private conversations in the 60s and 70s between individual managers in Kalundborg region. The exchange has since evolved as a result of good cooperation between companies' employees. The constant development of Kalundborg Symbiosis has been possible because the benefits of having an industrial symbiosis in Kalundborg has grown year after year, economically, environmentally and culturally. Kalundborg Symbiosis started in 1961, when Statoil (then Esso) needed water for their refinery in Kalundborg. The first tube in Kalundborg Symbiosis was completed between

Statoil and the nearby lake, Tissø. In 1972, Statoil agreement with Gyproc, a local plaster manufacturing company, for the supply of surplus gas from Statoil's production to Gyproc. Gyproc used gas (Today, natural gas) in their ovens for drying produced plasterboard. In 1973 Dong Energy (then Asnæsværket), Statoil water pipes and Gyproc would be the three partners in what would later become known as Kalundborg Symbiosis. During the year, several companies connected to the Kalundborg Symbiosis, and in 1989, the concept of 'industrial symbiosis' was used for the first time (Kalundborg Symbiosis, 2013). The exchange program today includes nine public and private companies in Kalundborg area, including the world's largest insulin producer, the world's largest enzyme producer, Northern Europe's largest wastewater treatment plant, the largest power plant and the largest oil refinery in the Baltics. All projects are environmentally and financially sustainable (Kalundborg Symbiosis, 2013).. Annually, the companies within Kalundborg exchange, 130,000 tonnes of combustible waste, 220,000 cubic meters of water and 4,500 households in Kalundborg receive district heat from Asnæs Power Station. Ammoniumthiosulphate byproduct is used in the production of approximately 20,000 tonnes of liquid fertilizer. Annually, 240 000 tonnes of C02 emissions are reduced, 3 million m3 of water saved, 30 000 tonnes of straw is converted to 5.4 million litres of ethanol, recycling of 150 000 tonnes of gypsum (Kalundborg Symbiosis, 2013).

Through building relations between independent companies in the same geographical area, to improve the environment, industrial parks like Kalundborg are becoming more common in an attempt to diminish the environmental pressure generated by industrial activities (van Leeuwen et al., 2003). Van Leeuwen et al. defines an EIP as “a clearly delimited territory where, by means of cooperation, firms adjust their activities with respect to one another in order to diminish the total environmental impact without affecting the economic vitality of the individual companies”

(2003, p. 148). Derochers (2001, p. 345) defines an eco-industrial park (EIP) as "a community of companies, located in a single region, that exchange and make use of each other's by-products or energy". Haskins (2007, p. 320) uncovers two similar definitions (1) "a community of businesses that cooperate with each other and with the local community to efficiently share resources [information, materials, water, energy, infrastructure and natural habitat], leading to economic gains, gains in environmental quality, and equitable enhancement of human resources for the business and the local community," (2) "EIPs as an industrial system of planned materials and energy exchanges that seeks to minimize energy and raw materials use, minimize waste and build sustainable economic, ecological and social relationships" (Haskins, 2007). Among these definitions it is clear that similarities exist and that generally speaking; EIPs are closed systems that share resources to limit waste. Klaundborg is an imperative EIP example to this study as it is the best known example and most utilized example of identifying and describing EIPs.

Figure 6: The initial exchange of wastes in Kalundborg EIP (Brand and Bruijin, 1999)

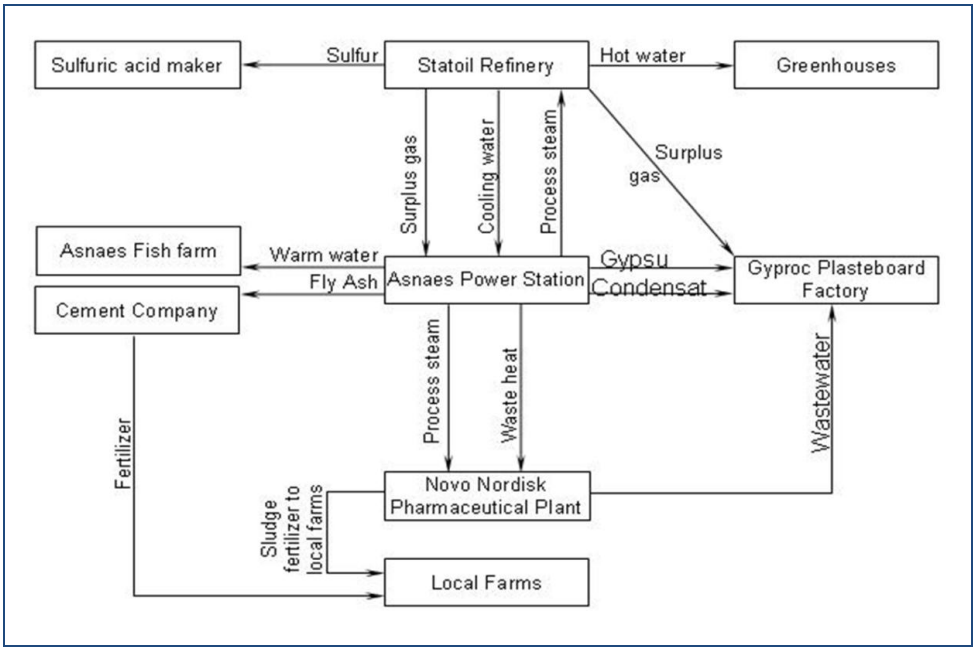
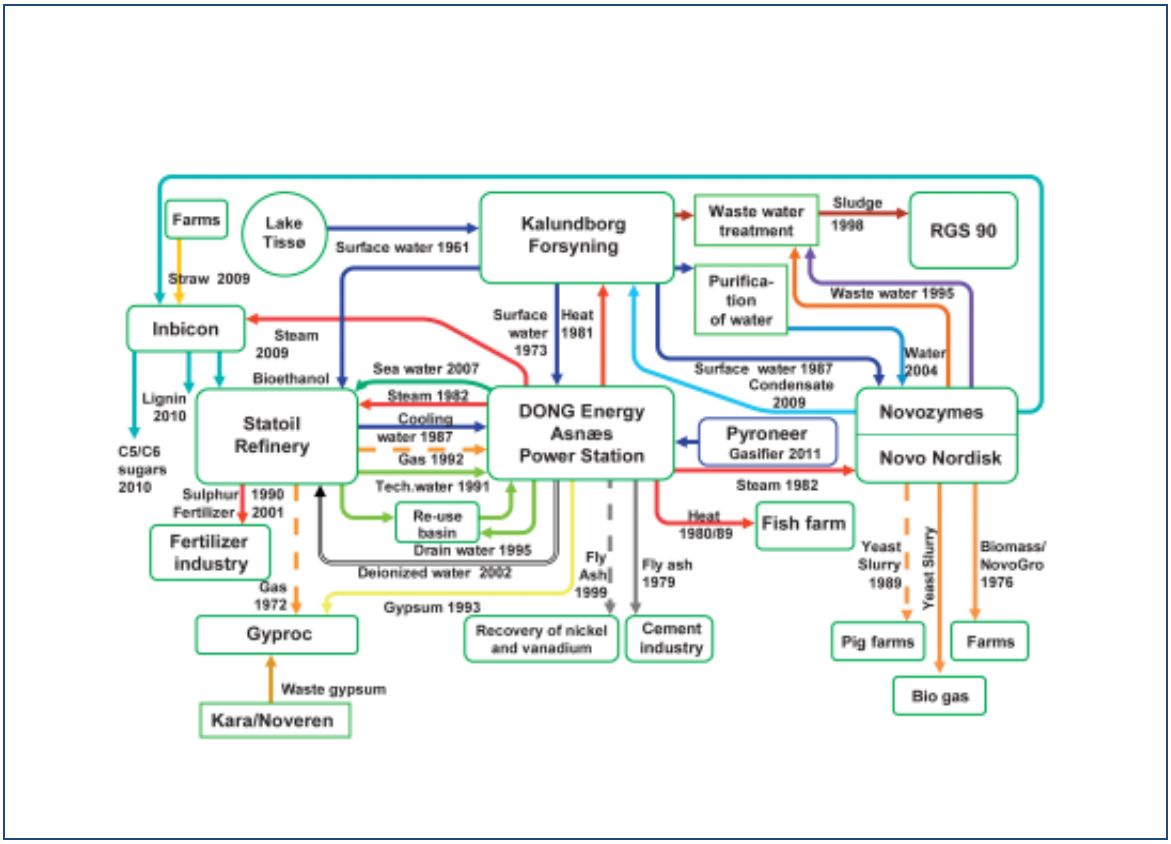


Figure 7: The exchange of wastes in Kalundborg EIP as of 2012 (Kalundborg Symbiosis, 2013)

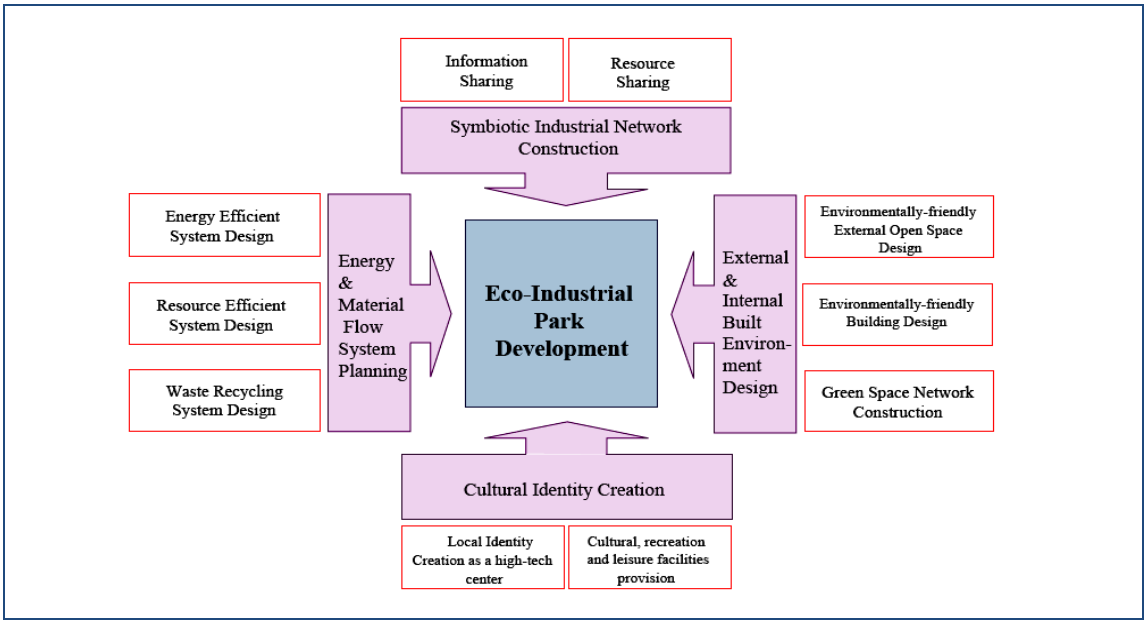


2.10.1 Sustainability and Eco Industrial Parks

To understand how EIPs can be sustainable, the following literature describes some principles incorporated into EIP design. First, Oh et al. (2005) explains that there are four major principles of designing EIPs. First, designing each industrial park as a mini-ecosystem and increasing its local self-sufficiency means changing current linear material flow systems into self-contained systems. Second, increasing the self-sufficiency of EIP implies a move away from the monoculture ethos (e.g. lack of mix of uses, housing types, etc.) in conventional industrial park's built environment, while at the same time maintaining and enhancing the quality and quantity of natural habitats. Uniformity in built forms should be replaced by a rich diversity; zoned uses by mixed uses, car dependence by choice of mode, sterilized species in poor

environments by local/regional diversity. Third, planning an EIP means establishing a set of effective symbiotic network of industries (i.e. energy efficient law material acquisition, production, distribution and pollution treatment network). Finally, increasing the self-sufficiency of an EIP, means increasing the community's sense of belonging (or cultural identity), primarily because this is one of the most important factors for increasing the commitment of local stakeholders to make them work (p. 271). Figure 8, shows these principles graphically. Outlining the design characteristics of EIPs is significant as they provide general criteria for the development and management of EIPs and how this development may influence the development of a waste exchange system. Cote and Rosenthal-Cohen (1998) summarize several essential characteristics of EIPs that have been proposed by a number of authors and include items such as; conserve materials through design and having a reduced environmental impact by treatment of wastes. Based on these examples it is very that EIP development and design is dependent on concepts as they relate to sustainability and resource sharing.

Figure 8: Components of a typical EIP (Oh et al. 2005)



2.11 Eco Industrial Parks and Waste Exchanges

One critical aspect of the EIP definition is the idea of exchanging materials among a group of companies within a designated geographic location. In some instances, this material may be the wastes or by-products of one company. In essence, the framework of an EIP is ideal for the creation of a waste exchange and the reduction or diversion of waste going to landfill or to be disposed. Therefore the definitions and concepts of waste exchanges should be well understood prior to the development of a waste exchange program. A brief summary of exchanges is presented below.

2.11.1 History of Exchanges

By-product or waste exchange is a long-standing concept. Companies and individuals have been exchanging surplus or unusable resources for as long as communities have existed (Emerald Group, 2010; Chertow, 2000; Vergara and Tchobanoglous, 2012). Communities and humans recognized that waste is inherently a commodity material and that the potential to divert it is typically limited only by the lowest cost alternative and that in most instances, this is the cost to transport and dispose of the material by traditional means. The provision of reutilization options for industrial by-products or "waste" was a natural extension of the services traditionally offered to the manufacturing sector by the many scrap dealers operating in local communities (Chertow, 2008). It is further argued that the potential for sustainable profits from waste diversion became apparent so activities such as de-packaging, blending, reprocessing, refining, direct reuse, recycling and more became common place in the private sector (Emerald Group, 2010). Much of the work to redirect materials from generators to potential receivers was historically done by independent brokers, with specialized knowledge of industry sectors or materials. Privately operated exchanges have been in operation for decades but were not adopted

by governments until the concept of the 3R's that material exchanges became broadly institutionalized as a means of promoting "reuse" (Emerald Group, 2010).

2.11.2 Passive vs. Active Exchanges

Argued by the Emerald Group (2010) resource or materials exchange services have evolved drastically since their introduction decades ago and typically evolve to become either "Passive" or "Active" depending on operating costs and legal or regulatory mandates. For instance, privately operated exchanges normally followed an "active" exchange delivery model whereas government services trended toward "passive" systems. In most instances for example, the delivery of exchange services by governments was mostly due to an identified need to reduce the impact of local manufacturers on municipal landfill. In general, passive exchanges require minimal staff to promote and maintain the service and are a rational choice of service for government agencies more concerned with being seen to be acting to address the issue than actual performance (Emerald Group, 2010). However, private sector operators prefer the model of active exchanges as an extension of their existing services due to a better success rate in achieving diversion and potential for profitability.

Table 1 lists the current exchanges in operation around the world. Of the 27 exchanges listed, 55% are operating as passive exchanges and 45% are operating as active systems. However, at the time of examination, agencies operating passive systems were doing so primarily as an obligatory government service with minimal performance expectations due to limited resources (Emerald Group, 2010). By comparison, the agencies operating active exchanges tended to be profit driven, private sector operations or government agencies with strong mandates to maximize diversion supported by adequate resources.

Early exchanges (developed twenty or so years ago) were limited in their ability to communicate potential exchange opportunities through direct contact, phone, fax and hard copy listings or

catalogues distributed either manually or by postal service. However, today advancements in the internet have revolutionized the delivery and success of exchanges. The availability of the internet has become the primary means of promoting and listing exchange services and available materials. For example, the CalMax materials exchange program based out of California reported that the growing presence of independent ruse/resale sites such as *Kijiji* and *Crag's list* has eliminated the role of CalMax in diverting residential materials and much of the durable goods from local businesses.

However, this trend also represents a growing challenge associated with the internet based exchange service; private passive exchanges are seen by some operators as taking business away from the actively managed exchanges.

Table 1: List of Global Active Exchanges (Emerald Group, 2010)

American	Canadian	Australia/New Zealand	Europe	Africa
• Northeast Recycling Council - Vermont MEX • Arkansas Wood Waste & Materials • CalMax Materials Exchange • RENEW • Tennessee Materials Exchange • National Industrial Symbiosis Programme • Southern Waste Information eXchange Inc • The Free Market	• Calgary Materials Exchange • The Cariboo Regional District Waste Exchange • Recycling Council of BC Materials Exchange • Cdn. Env. Reg & Compliance News • Ontario Waste Materials Exchange • IWasteNot Systems • Dalhousie/Burnside Eco-Industrial Park • FABR Residential Exchange • RecycleNet Corporation	• Terranova Waste Exchanges • Wastepro Australia • Waste MINZ	• Waste Matchers (UK) • Lancaster County SWA Waste Exchange (UK) • Eastex National Materials Exchange (UK) • TradeBoss (Hungary) • Der Grüne Punkt DSD GmbH (Germany) • Kalundborg Symbiosis (Denmark)	• Integrated Waste Exchange (South Africa)

2.11.3 Canadian Eco Industrial Parks and Waste Exchanges

Kalundborg EIP in Denmark is essential as it provides a background synopsis of how EIPs and Symbiosis generally work. However, due to the Canadian setting of the Toronto Pearson case study, several Canadian EIPs are summarized in the following sections. These examples will help to draw up the Canadian context for EIPs and waste exchanges and what they involve.

Calgary Materials Exchange

Established in 2003 under the non-profit urban environmental organization Green Calgary, the Calgary Materials Exchange (CMEX) assists companies with finding alternative disposal options for their waste. CMEX provides businesses in the industrial, commercial, institutional, construction and demolition sectors with the knowledge and tools required to reduce, reuse and recycle (Calgary Materials Exchange, 2013).

The CMEX is governed by the Green Calgary board of directors as well as some volunteers and staff. CMEX has 4.5 paid staff directly work on the exchange program, 1.5 for waste audits, and 2 staff provide resources, plus one supervisor. This is an actively managed exchange with managed listings plus staff physically going to companies. Funding for the CMEX is available through the City of Calgary, corporate sponsors, memberships and fees for waste audit services. Exchange costs estimated at $60-75,000 CDN annually of a $350,000 total program budget. The membership ($100) and sponsorship funds go directly to running the CMEX program.

All business in the Calgary and surrounding areas may use the exchange program, but is completely voluntary and is the responsibility of the materials recipients and sellers to arrange payment terms and transfer logistics. Cardboard, paper, wood, paint, plastic, organics, oils/petrochemicals textiles, rubber, office equipment, metal, construction waste, glass, electronics, minerals, pallets, office furniture, misc. materials include the majority of materials exchanged. To date more than 280,000 kilograms of plastic has been diverted from the landfill, while saving companies $14,000 in saved disposal costs. Web page, email and telephone provide the main stakeholder involvement. The initial focus group was invited and asked for challenges and goals. Steering committee worked 18 months to guide development. Technical committee also formed at inception. Steering committee still meets occasionally. There are a total of 509

companies in the CMEX with a total of 5235 exchanges. Tonnes diverted by the CMEX total 10,819.72 resulting in a total cost savings of $754,701.54 (CDN). CMEX uses software provided by *IwasteNot Systems* specifically designed for waste exchange operations. Websites are modular and can include sections for: Online material (waste) exchanges, directories for reuse/recycling businesses and non-profit organizations, events listings and recycling links. The software can report on the weight, waste management savings, greenhouse gas reduction and potential carbon credits produced by the exchanges. The CMEX is considered a high level active exchange as it provides the following services to its members:

- Recommendations and referrals for waste diversion solutions (e.g. recycler contact information).
- Visual Waste Assessment: A facility tour to identify diversion opportunities and solutions.
- Recycling Report: A comprehensive report to provide recommendations for implementing an effective recycling program and to quantify diversion initiatives. A calculation of ecological benefits achieved will be provided to members at the 1-year renewal date.
- Waste Measurement Toolkit: A standardized methodology of waste measurement that quantifies the amount and composition of waste and diverted materials/ recyclables and creates a baseline summary to measure ongoing performance.

Recycling Council of BC Material Exchange

Established in 1985, the Recycling Council of BC Material Exchange (RCBC MEX) is a free province-wide service facilitating the reuse and recycling of products and materials destined for the landfill (Recycling Council of BC, 2013). The program has a free online listing service which includes both the Residential Reuses Program as well as the BC Industrial Materials Exchange (BC IMEX). The BC IMEX portion of the RCBC MEX began its operation in 2007. The RCBC IMEX and is run by two full-time staff and is controlled by a Board of Directors. Funding comes from the BC Ministry of Environment as well as corporate sponsors and municipal funding. Materials include all or any, including chemicals, with exclusions on; live

animals, illegal goods, hazardous materials, new (unused) items. The RCBC MEX volume of materials varies seasonally, but there are usually 20-40 new listings per day and 4-5 successful transactions/day. In the last seven years (2004-2010) the RCBC Exchange programs have diverted a total of 558 tonnes of waste from BC landfills. The program is considered an Active exchange as they call to follow up on all approved listings.

Burnside/Dalhousie Eco Industrial Park Efficiency Program

The "Industrial Park as an Ecosystem" project in Burnside Industrial Park began in 1992 as a multi-disciplinary research initiative investigating the possible application and interpretation of ecological characteristics and functions to an industrial park (Cote and Rosenthal, 1998; 2003; Eco-Efficiency Centre, 2013). The Eco-Efficiency Centre, created in 1998 is concerned with smart business practices that result in less waste through design, operation, maintenance and symbiotic relationships. Clients include the 1400 businesses within the Burnside Industrial Park as well as an additional 10,000 businesses in Halifax Regional Municipality. The Centre was founded upon the principles of eco-efficiency, a management philosophy that seeks to achieve strengthened financial performance by minimizing the resources necessary to produce, consume and dispose of a particular product or service. This in turn minimizes the negative environmental impacts. The Centre was established in 1998 as a partnership between Dalhousie University and Nova Scotia Power Inc., and is supported by private corporations, governments and foundations. The centre encourages businesses to join the Eco-Business Program in which companies are provided with continuing support to a smart growth network of businesses. The Centre was founded upon the principles of eco-efficiency, a management philosophy that seeks to achieve strengthened financial performance by minimizing the resources necessary to produce, consume and dispose of a particular product or service. The Centre is run by 6 full-time employees as well as 2-3 co-op students and minor administrative support from the university. The centre received

an initial 3 year budget of $180,000/yr CDN supported by private corporations, governments and foundations such as Nova Scotia Power. Although, the centre does not provide a formal waste exchange program, the staff conduct site visits to identify opportunities to reduce costs, minimize waste and improve resource efficiency and assist with carbon foot printing to businesses in Burnside Industrial Park and the surrounding area. These site visits are apart of the Centers *Material Exchange Workshop* program. The centre co-hosts with local regional development authorities and waste-educators to provide material exchange workshops across the province of Nova Scotia. The workshops are 2 to 3 hours in length, are free and open to all small to medium-sized enterprise owners or members. The workshops include presentations on industrial symbiosis practices. Following the presentations a networking or "speed-dating" session takes place in order to create commercial opportunities, increase profit and boost economic development between business participants. The goals of the workshop include:

- Raise awareness about waste and resource management best-practices
- Discuss waste and material exchange avenues
- Create connections between businesses and facilitate commercial opportunities

Ontario Waste Materials Exchange

The Ontario Waste Materials Exchange (OWME) began its operation in 1984 and was designed to facilitate the reuse and recycling of industrial by-product materials (Great Lakes, 2013). In 1997, the OWMEs operation and responsibility was transferred to the Ontario Centre for Environmental Technology Advancement (OCETA). OCETA claims that the purpose of the OWME is to create a network that allows waste products or outputs of one industry to become the raw materials inputs of another. Through the exchange network, OCETA provides generators with access to reuse and recycling markets, and users with access to the material supply sources.

In the Spring of 2001, OCETA received funding from the Volunteer Action On-line Program to strengthen its on-line capabilities and develop the infrastructure required to increase voluntary participation with the Exchange Network. These new developments allowed the Exchange to expand its traditional sole focus of tracking tonnes diverted from landfill, to become more of an information clearing house on alternatives and opportunities to the production and diversion of materials traditionally destined for landfill. It is important to note that information presented above depicts an operational exchange. However, all website links and phone numbers uncovered are unresponsive or inactive at this time. In addition, the Emerald Group stated in their 2010 report that staff reduction three years ago (2007) resulted in the exchange maintaining a passive presence on the net. Evidence in the data as well as a lack of web presence suggests that despite some available information, this exchange is no longer in use or functioning.

Quebec Industrial Waste Program (BRIQ)

In the fall of 2005, the *Centre de transfert technologique en ecologie industrielle* (CTTÉI) based out of Quebec launched a new tool designed to support industry efforts in managing their waste and diverting industrial waste from landfills (CTTÉI, 2012). This tool became known as the *Quebec Industrial Waste Exchange Program (BRIQ)* whose basic principle is to make the waste of one industry available to other industries for reuse as raw material or recycling. This material exchange occurred through a controlled access web site managed by a third party partner known as TTCIE (Technology Transfer Centre in Industrial Ecology) who encouraged the exchanges by putting the appropriate industries in contact, by tracking the results of the volumes of material recycled and by soliciting new members to join in. Companies pay a yearly membership fee that includes unlimited access to the data, a plant visit to identify all input and output material, automatic e-mails informing the members of a new entry corresponding to their

needs and monthly news. For an additional fee, TTCIE can assist members in characterizing their wasted, in finding alternative disposal options and in developing value-added products form their industrial waste. To this date, over a hundred of different waste materials are available on the website. Several exchanges have been completed diverting several hundreds of tons of industrial wastes from landfills. Since 2005, enhancements to increase its user-friendliness and performance have made the BRIQ a tool to determine potential synergies between businesses in a given area. The program also makes it possible to create profiles of new businesses whose activities could be complementary to the ones already being carried out on the territory. These advances and the development of a rigorous methodology led the CTTÉI to carry out the first by-product synergy project in the Bécancour industrial park with the funding and support of several local and government partners. The project involved 12 Centre-du-Québec businesses and identified almost 40 synergies, which, once applied, will represent earnings of $1.6M and savings of at least 2,000 CO2 per year for participating businesses. In addition, CTTÉI advocates that, "These synergies create *industrial symbiosis* – the exchange of the water, energy and/or materials (i.e. production waste) used for industrial activities." CTTÉI also recognizes that a by-product synergies project can generate several environmental and social benefits for the businesses involved and the community including:

- New business networks;
- Local waste management and limited transport costs;
- New income by reselling materials or avoiding certain elimination costs;
- Preferred rates for eliminating materials in bulk and group rates from service providers (economies of scale);
- Lower purchase costs of new materials for businesses that integrate industrial waste into their production processes;
- Increased competition among businesses through process optimization;
- Enhanced corporate images through environmental impact reduction;
- Increased appeal of the industrial zone or territory;
- New business dynamic;

- Profiles of the companies to attract so as to ensure their activities are complementary to those of the businesses already present on the territory;
- More diverse industrial activities;
- A new culture of collective resource management (water, energy, materials);
- Companies become accountable in their steps towards sustainability.

2.12 Waste Regulations in Ontario

To understand how a waste exchange program within an EIP may influence or inform municipal solid waste planning, the existing regulations and legislation concerning waste management must be understood. These regulations are critical as they outline how waste is currently regulated and the legal requirements of waste management.

2.12.1 Canadian Environmental Protection Act (CEPA), 1990

The one major overlying waste mandate is the provincially regulated *Canadian Environmental Protection Act (CEPA)* officially instituted in 1999 (Environment Canada, 2011). The CEPA is an important part of Canada's federal environmental legislation aimed at preventing pollution and protection the environment and human health. The CEPA sets out the general prohibition against contamination and states that "No person shall discharge into the natural environment any contaminant, and no person responsible for a source of contaminant shall permit the discharge into the natural environment of any contaminant from the source of contaminant, in an amount, concentration or level in excess of that prescribed by the regulations." (Emerald Group, 2010; Service Ontario, 2011).The Environmental Protection Act is Ontario's key legislation for environmental protection. The act grants the Ministry of the Environment broad powers to deal with the discharge of contaminants which cause negative effects. The act specifically prohibits the discharge of any contaminants into the environment

which cause or are likely to cause negative effects and requires that any spills of pollutants be reported and cleaned up in a timely fashion. Ontario's Environmental Protection Act has the authority to establish liability on the party which is at fault, including liability for corporate officers or directors who have failed to take all reasonable care to prevent unlawful discharges of contaminants into the environment. Under the EPA there are several regulations associate to the management of waste discussed below.

History of the CEPA

The original *Canadian Environmental Protection Act*, commonly referred to as "CEPA" was developed in the mid-1980s in response to growing public concern about the presence of toxic substances in the environment (Environment Canada, 2011). In 1985 the federal government established two task forces to review CEPA's predecessor, the *Environmental Contaminants Act*, and to develop a better approach for dealing with toxic substances. The task forces concluded that the existing legislation was inadequate for dealing toxic substances and that a new, more comprehensive approach had to be developed to manage the full life cycle of toxic substances from "cradle to grave." Acting on the task forces' recommendations, the federal government issued preliminary draft environmental legislation in 1986. The Canadian Environmental Protection Act, was then produced in June 1987. CEPA was a complex piece of legislation that consolidated selected provisions and laws administered by Environment Canada. It replaced the *Environmental Contaminants Act* of 1975, and subsumed the *Clean Air Act*, the *Ocean Dumping Act*, the nutrient provisions of the *Canada Water Act* and certain provisions of the *Department of the Environment Act*. In 1994, a recommended new approach for CEPA was developed which would have sustainable development as its overarching policy goal and which would be supported by the following key principles:

- pollution prevention,
- the ecosystem approach,
- biodiversity,
- the precautionary principle, and
- user/producer responsibility.

2.12.2 Ontario 3 R Regulations

In 1994, the Ontario Ministry of the Environment enacted the 3Rs Regulations (Regulations 101/94 to 105/94) under the Environmental Protection Act to increase the diversion of residential, Industrial, Commercial and Institutional (IC&I) and Construction and Demolition waste from disposal. These regulations are the only major regulations that are intended specifically for the management of waste Ontario. It is critical to highlight the existing regulations in order to understand how waste is currently controlled and managed. A description of the Ontario 3 R regulations can be viewed in Appendix B.

2.12.3 Waste Diversion in Ontario

The primary objective of the 3 regulations discussed was to ensure that Ontario reduced municipal waste going to landfill by 50 percent by the year 2000. Since this target was not accomplished, the Province of Ontario promulgated the *Waste Diversion Act* and established Waste Diversion Ontario.

Waste Diversion Act, 2002

The Waste Diversion Act was instituted to promote the reduction, reuse and recycling of waste and to provide for the development, implementation and operation of waste diversion programs. Waste Diversion Ontario (WDO) which is a non-crown corporation and was created under the *Waste Diversion Act (WDA)* on June 27, 2002 and was established to develop, implement and operate waste diversion programs for a wide range of materials (WDO, 2011). The largest component of the Waste Diversion Act is the *Blue Box Program Plan* but includes

other regulations which assist with the diversion of various materials. These regulations can be viewed in Appendix B.

2.12.4 Environmental Assessment Act, 1992

Ontario's Environmental Assessment Act originally passed in 1992, requires federal departments, agencies and corporations to conduct environmental assessment of any major public sector undertaking that has the potential for significant environmental effects. This includes public roads, transit, and wastewater and stormwater installations. Environmental assessments determine the ecological, cultural, economic and social impact of the project. Environmental assessment is a key part of the planning process and must be completed before decisions are made to proceed on a project (Ministry of Environment, 2012).The act exists to "provide for the protection, conservation, and wise management of Ontario's environment". The act mandates clear terms of reference, focused assessment hearings, ongoing consultation with all parties involved - including public consultation - and, if necessary, referral to mediation for decision. The Environmental Assessment Act also establishes a "Class Environmental Assessment" process to streamline the planning of municipal projects - including some road, water, and sewage and stormwater projects.

2.13 Waste Audits and Tracking

The province of Ontario under O. Reg. 102/94 requires waste audits to be done for various Institutional, Industrial and Commercial organizations. This requirement suggests that there is significance in tracking ones waste. Therefore a summary on waste auditing and tracking is presented below to provide a background to this requirement. Lynes (2006) explains that a *Waste Audit*, is as its name suggests, is a survey of what an individual or a business throws away. Most simply, waste audits measure quantity, volume and composition of garbage from a specific

site. Lynes further argues that waste audits are significant for several reasons which include; educating management and employees about waste, identifying potential savings for businesses and companies and resulting in more efficient customer service and increased employee satisfaction (pg. 24). Not all waste audits are quantifiable in nature as some people during the auditing process helping to formulate extensive knowledge about the entire waste process. Several examples exist in the literature where auditing has been used to reduce waste and help cut costs associated to waste. In Taiwan for example, the government realized the significance of tracking and reporting waste. In 1988, the Industrial Waste Controlling Centre was created and has recently been expanded from an original 'control' by report to 'prevention' by aggressive tracking (Young, 2010, p. 237). The regulated hazardous waste is controlled and tracked from source to disposal and the waste producer, transporter and final disposal party must report the quality and quantity to the Centre via the internet and currently, there are about 13 500 industries regulated and mandated to report (p. 242). As a direct result of the control center in a span of 20 years, the MSW in Taiwan has changed from 100% dumping to almost 100% properly disposed including 37% minimization/Recycling. Furthermore, a center for waste exchange was established in 1987 and has successfully matched 563 000 ton of wastes. Young (2010) suggests that for ultimate success of reaching the zero waste goal governments should promote information and services on waste exchange as well as information on techniques, case studies illustrating technical feasibility and that waste exchange should involve aggressively matching the demander and supplier instead posting information and waiting for clients (p.242). Similar to the examples highlighted in Taiwan, Goren (2010, p. 443) argues that Turkeys Solid Waste Management Systems have been steadily progressing towards increased diversion, however some developments are required and argues that a waste monitoring system be initiated in order

to create an inventory system with the establishment of electronic databases. Godfrey and Scott (2010) explore the research question: *'Can the collection of data for a national waste information system, change the way waste is managed in South Africa, such that there is a noticeable improvement'* in their paper and did so by analyzing the South African Waste Information System (SAWIS). One major focus of this study was on the ability of companies to collect and organize data about waste and found that the main driver of data collection was financial sustainability such as reduced operational costs (p. 501). Many managers of the recycling companies also claimed that they collect data on recycling to help reduce costs of waste overall waste removal (p. 506). The authors also explored constraints to data collection within both private and public waste facilities and found that a main constraint is lack of 'equipment', particularly IT (computers, internet and email connectivity) and 'institutional capacity' (availability of staff, the high staff turnover and a shortage of skills within the organizations to collect and interpret the data) (p.506).

2.14 Conclusions from the Literature

The literature presented has provided key information regarding several major themes. Some of these major themes include: Municipal Planning, Eco Industrial Parks, Waste Exchanges and governmental waste regulations. To fully study how the development of a waste exchange may inform municipal solid waste planning these themes must be explored together. The concepts and theories explored in the Literature will provide the basis for developing the case study and will help to inform the project in its conclusion.

3.0 Methodology

3.1 Overview

To adequately explore the research questions of this study and to uncover the feasibility of establishing a working waste exchange within the Toronto Pearson Eco Park, this study utilized qualitative research approaches. Qualitative research is typically used when variables and theories are largely unknown and almost always uses smaller data sets that center on interactive research which provides deep, information-rich data (Cresswell, 2009). In general two qualitative techniques were used and included; primary research of existing documents as well as semi-structured interviews.

3.3.1 Initial Research

The primary objective of this study was to determine how waste exchanges might inform and influence municipal planning, more specifically municipal solid waste planning. To determine this objective, a working waste exchange within the Toronto Pearson EIP was developed. However, prior to the development of the exchange, background research was required to understand what exists within the Toronto Pearson Eco-Business Zone. Primary research of existing documents including the Partners in Project Green website and the various annual and strategic reports located within the website were analyzed. These documents provided initial data on the types of business, organizations and strategies that exist throughout the Toronto EIP. In addition, this primary data provided readily available information regarding the Partners in Project Green Organization. Analysis of the various documents established that no aspect of the website and its primary documents deal with waste exchange suggesting a prime opportunity for promoting and establishing a waste exchange program. There are also several directories on the website such as the *Green Business Directory* which helps to serve people looking for Green Operating Businesses. However, this directory does not deal with waste or

waste management in any way. Generally speaking, these examples suggest that although the Partners in Project Green website is oriented and equipped to deal with and promote the greening of businesses, there is a lack of information focused on waste management. This lack of focus on waste management suggested a prime opportunity for the development of a waste related tool or exchange program.

3.3.2 Communication and Outreach Methodology

Once the general methodology was chosen and the company outreach list was created a communication plan was established. The purpose of the communication plan was to inform the approach of contacting companies and to ensure the most sufficient steps would be taken. This plan not only provided the general approach for media and outreach communications, but also identified how the researcher or interviewer would proceed with all things related to data collection, follow up and data storage. The Communication plan developed the steps of the outreach which are summarized in the 7 steps below.

1. Define Region and Select Firms
    a. Determine the number of Firms to contact given the magnitude of the project
    b. Analyze existing firms within the area
    c. Select firms based on recommended guidelines
2. Contact Businesses by letter
3. Officially launch the project
4. Validate the interest of contacted firms
    a. Firm management can assign a contact person
5. Send the questionnaire by email to allow the contact person to gather necessary information
6. Get in touch with the contact person by phone to collect the information on materials
7. Visit the business

3.3.3 Interviews

Once the background research was complete and a communication plan set data collection could begin. The major form of qualitative research method utilized was the use of the semi-structured *Interview* including both *face-to-face* and *phone interviews*. Creswell (2009)

explains that in qualitative interviewing, the researcher conducts face-to-face interviews with participants, interviews participants by telephone or engages in focus group interviews. These interviews involve unstructured and generally open-ended questions intended to elicit views and opinions from the participants. According to the literature, interviews are one of the most flexible forms of data collection and are one major reason for which interviews were chosen as a primary research method for this study (de Leeuw, 2008, p. 31). For example, face-to-face interviewing has the highest potential regarding the types of questions asked and the complexity of questions as it allows for great control over the line of questioning through clarification and probing. According to de Leeuw, the interviews greatest asset is the interviewer's presence as they can assist in explaining or probing difficult and complex questions. However, their presence is also seen as a major weakness to the approach as it may influence or bias answers resulting in survey errors (Creswell, 2009). Additional benefits of utilizing interviews in research include; consistency in answers. For example, respondents that are interviewed by the same interviewer tend to have more similar answers resulting in consistent and sound study results. Further, respondents can also provide historical information and as much additional information as they would like. Drawbacks of interviews include that respondents feeling inhibited to answer sensitive questions. Interviews also take a lot of care and are costly to ensure quality and can also require heavy administrative duties to ensure interview material is mailed and received on a timely basis. In general, interviews are very costly and time consuming as they often require travel. Interviews can also present additional bias as the information is filtered through the interviewer. And lastly, not all people being interviews are equally articulate and perceptive therefore resulting in some survey bias.

Telephone interviews chosen as a data collection method in this study are less flexible than face-to-face interview and their major drawback is the absence of visual cues during the interview (de Leeuw, 2008). However, just like face-to-face interviews, interviewers can assist respondents in understanding questions and can probe for answers. Telephone interviews are less costly as there are no travels expenses associated and can be flexible as to when they are done. In addition, numerous phone interviews can usually be done over a short period of time resulting in a less expensive survey method. Author John Creswell of *Research Design (2009)* argues that when conducting qualitative research that a natural setting is almost always used. It is suggested that this allows individuals to act and behave within their natural context. This means that qualitative researchers tend to collect data in the field at the site where participants experience the issue or the problem. In the case of this study, the interviews conducted face-to-face were always done in the natural setting (at the company site/facility) allowing for ease and comfort for the respondent. Because this study involved numerous companies with varying business structures and contact persons, flexibility was a critical component needed to frame the study questions. Therefore it was determined that a semi-structured approach for the interviews would be taken. This meant that the same set of questions was presented to each company contact, but that they were not always presented in the same order or asked the exact same way to every contact. This flexibility ensured that a full description of the materials and company production was identified. In addition, probing was utilized to assist the company contact in understanding what was being asked or to identify additional materials for the exchange that may not have been initially presented.

Interviews were also chosen as the main form of methodology based on conclusions formed from the waste exchange program BRIQ. CTTÉI determined that several methods of data

collection are more effective than others and reported the following on the various types of methodology:

- Article in electronic newsletter = no effect
- Email or electronic survey = response rate of 1.5%
- With a letter sent to chosen business signed by official in addition to an official press release followed by a phone call results in = response rate of 63% (following the phone interview a meeting or site visit usually took place).

It became obvious that interviews would be a critical methodology to obtain greater response rates and that an interview by phone or site visit was incredibly more effective than an online survey. Further, CTTÉI found that the site visit resulted in the best data quality followed by good data quality from phone interviews and poor data from the online survey. Using a questionnaire developed previously developed by CTTÉI, the purpose of the interview was to seek information to understand the entire waste management process at each company. Understanding the entire system was critical in the building of the company waste database. To build this database and to understand the waste management processes, the questions ranged from simple demographic data including names and phone numbers of the company contact as well to detailed questions regarding the physical make-up of their waste products. The data collected from the interviews also helped to establish a simple waste profile of each company and contributed to a larger database of all of the companies contacted. The questionnaire and data collection sheet can be viewed in Appendix A. According to Creswell (2009) a typical semi-structured interview data collection approach includes the following; conduct a semi-structured interview, audiotape the interview, and transcribe the interview. It is important to note that for this study the interviews were not audiotaped and therefore no results were transcribed. The absence of transcribed notes and usable verbatim quotes in this study presented a slight limitation and is further discussed in study limitations in section 3.4.

3.3.4 Site Visits

Throughout the data collection process the company site visit played an integral role in getting companies involved in the waste exchange program. Prior to the site visit a phone call was exchanged between the company and PPG thus providing PPG with the needed demographic data including name, phone and address. During the phone call information was given about the process and the waste management system. In some instances all of the information was not gathered in its entirety because the process was too detailed for a phone conversation or contacts preferred to discuss in person. In addition some contacts wished to provide a site visit to provide the in-person. In general the reasons for the site visit included;

- Companies were unsure if they had covered all of their waste products;
- Companies preferred a site visit over a phone interview;
- All Companies were offered a visit automatically during the phone interview;

Patton (2002) explains that when conducting qualitative interviews the "informal conversational interview is the most open-ended approach… and offers maximum flexibility to pursue information in whatever direction appears to be appropriate" suggesting that this style of interviewing allows for natural flow, but also provides the interviewer opportunity to probe and direct the interviewee to give specific or certain information (p. 342). Just as Patton describes, the site visits in this project often were very informal and simply involved the interviewee explaining the process of their production in an office setting followed by a walk-thru of the plant or factory. At these site visits the data collection sheet and questionnaire was often used informally as the interview was conducted more in a conversational manner. For example, the interview began with a description of Partners in Project Green and the goals and objectives of the by-product waste exchange program so that the companies were aware of the project and why their company was contacted. This step of the interview was critical because in some

instances due to availability, the interviewee was a different person then originally contacted. The facilitator would then ask the company representative to explain the production process and to identify the major wastes or waste challenges of the company. In most cases this process carried on in a conversational manner and any additional questions or information needed was followed up by a phone call or email.

3.3.5 The Database

With the procurement of a contract with CTTÉI, it was determined the TRCA would be able to utilize the computer database called the *Synergie Quebec Manage Tool* developed by CTTÉI of which they utilized for their exchange project BRIQ. The use of the database and its components are described in the sections below.

The database has several main components of which the project facilitators manually manage and control. These components include:

- Synergy Groups:
  - News
  - Partners
- Synergies:
  - Matching Rules
  - Synergies
  - Ads
  - *Auto Matches*
- Members:
  - Companies

Once data was collected from a company the data was entered into the "Member: Company" category. This section of the database required mandatory information for the company including:

- Name
- Address, City, Province, Country and Postal Code
- Username, Password (created for the Company)
- Contact Information (Title, Name, Email Address or Phone Number)

Once a company was entered an "Ad" could then be created within the "Synergy" category of the database. The "Ad" section is where the raw data collected is entered. Mandatory fields for this category include:

- Offer or Request (Main Material)
- Company
- Generic Name (of Material, i.e. Wood Chips)
- Material Category (i.e. Soil, Wood, Acid, Metal, Plastic etc.)
- Classification (i.e. Hazardous Material, Non-hazardous etc.)
- Quantity (i.e. Big Dumpster (360L), Kilograms, Tonnes, Pounds, Litres etc.)
- Frequency (i.e. Daily, Weekly, Monthly, Annually)

Once this data was entered into the database, the database matched companies based on similar requests and offers of the Material Category. The matches or "synergies" were then created and were located in the "Auto Matches" component of the database. Within the Auto Matches a screen is then presented which shows an "Offer" of material from *Company A* and then a "Request" for a material of *Company B* – the material of which are the same. This match is referred to as a "Synergie." The next step of the database required the facilitator to "Create" the match. This step requires the "Synergie" to be reviewed by the facilitator and once approved they can finalize the match by clicking the "create" button. Once the match is "created" an automatic email is generated to each of companies within the database informing them of the match and referring them to the website for more details. However, it is important to note that the last step of "creating the Synergie" was not completed due to technical difficulties and will be explained in the *issues* section below.

3.3.6 Issues with the Database

Auto Match Issues

The step in which the facilitator is suppose to "create" the match was never a step which this project utilized. However, this step was completed manually by the facilitator who sent out

emails directly to the company. Because CTTÉI is a Quebec based institution all of the database tools were originally produced in the French language. Once the contract was made with TRCA, the website and database were to be translated into English language for the use of the TRCA members who were not fluent in French, but also so that companies would be able to access the site. It was decided that the website and database which is split into two parts would be translated separately. The one part of the database is strictly for the log-in and use of the facilitator, the second part designed only for the use of the companies. Due to staffing delays as well as technical difficulties, the website and database section designed for companies was never translated in time for the project launch. In addition, the automatic email generation would not produce emails in English. Due to the fact that the project had already been officially launched it was decided that the facilitators would simply email out companies themselves explaining the match made and that all communication related to the project would made directly through the facilitator.

The second major issue with the *Auto Match* feature of the database was the fact that the person inputting the data had to be quite specific and knowledgeable about the physical make-up of the product (waste), which in some cases was difficult. For example, the *Auto Match* created synergies based on the "Material Category" section in the "Ad" component of the website. This feature is quite specific and requires the exact name for the material being entered into the database. For example, if a company was offering plastic as a waste, plastic cannot just be entered into the website. The website instead would prompt for the facilitator to input the exact type of plastic ensuring that the match is as effective as possible. For example, if one material category offer for *Company A* was plastic the website would prompt if it was *Polystyrene, Polypropylene, Plastic Film, Mixed Plastics, PVC* etc. What becomes the issue is that there can

be numerous, and in some cases hundreds of different types of the same material and if neither the company contact nor facilitator knows the data, the material cannot be entered properly. To demonstrate, if *Company A* is offering polystyrene plastic and *Company B* is offering polypropylene plastic then a match will not be created even though they are both offering a plastic. During the first stages of initial data collection this step was often missed as companies giving data would not be entirely specific with the types of materials they were offering or requesting. In other cases companies did not know what kind of plastic it was. For example *Company X* produced cookies and used cookie trays made of plastic to ship the product. In some instances the plastic trays became broken or misshaped creating a major waste for the company. If this company did not know the exact type of plastic the tray was, the facilitator would need to make an educated guess or do some research to determine the type of plastic it was.

The issue of "guessing" materials dictates that it would create major issues with establishing the synergies; however, the first issue described with the *Auto Match* helped to reduce this problem. For example, as mentioned, the first problem as explained above identified that the emails which were supposed to be automatically generated were never used due to translation problems which resulted in the facilitator taking the lead on this task. The fact that the facilitator took the lead on the emailing meant that any discrepancy in data input could be dealt with by manually screening the Auto Matches and by manually creating synergies. For example, if the facilitator knew that one company was requesting plastic (polystyrene) and a company was offering plastic (with the specific unknown) the facilitator was able to manually identify these requests and offers and then manually contact each company so that a possible match was not missed. It is also important to note that although the database required more manual review and labour it meant that certain matches could be established even if the database did not necessarily automatically match them.

As mentioned earlier in this section, the website required specific data which in some cases meant that certain companies although a possible match were not necessarily matched. For example, many companies requested or offered skids as a waste. Some of these companies required a very specific size for their product and some would take any size. This meant that if two companies were matched in this scenario but the skids were not of the right size and could not be used, the facilitator could easily email all the companies who requested skids in anticipation of other possible matches.

In general, although it seemed that the increased manual labour would be a disadvantage to this project, it turned out to be a benefit as the matches could easily be tailored or changed if needed. Essentially the website and database was constantly reviewed for quality matches and for the possibility of increased synergies adding to the credibility and eventual success of the working by-product exchange system.

3.4 Sampling and Methodology Issues

During the outreach portion of the project locating key-informants of companies for the interviews in some cases became difficult. For example, in some instances a contact in the database had moved positions at the company or had outright left the company. In other cases the contact in the database knew very little to nothing regarding the company's wastes. In these cases *snowball sampling* was used as means of contacting other key-informants. *Snowball sampling* is an approach used in qualitative research to locate information-rich data and often involved asking well-situated people if they know someone who would know the answers to the questions being asked (Patton, 2002). As recommended by CTTÉI in their initial review of the methods and outreach, the online survey which was an adaptation of the interview questions and was originally planned to be used, was not used or promoted for this project. It seemed that in

general most companies opted for a phone interview or a site visit and there was never a request to use the online survey tool. This suggests that the online survey tool in this type of project is obsolete and suggests that companies prefer talking to an actual person. In this case, it is clear that the face-to-to face contact and phone interviews yielded a much higher response rate. It is also important to note that the interviews are too seasoned with inherent biases that stem from this sampling method.

First, interviews can offer great flexibility and communication; however these characteristics can also be a disadvantage. For example, respondents may feel inhibited to answer sensitive questions and may give more desirable answers instead. Also due to the semi-structured nature of the interviews, grouping answers based on similarities may become an issue because the questions will not be asked the exact same way with every respondent (de Leeuw, 2008). To avoid these issues and to also avoid *construct validity* (ensuring the question measures what it is supposed to) pre-testing the questions became an important component. As reported CTTÉI had utilized the questionnaire prior with their project BRIQ and therefore the questions had been tested throughout the duration of their project. This testing helped to ensure that the questions were comprehensible and also ensured that the information is easily presented to the interviewee so they understand the questions and can provide answers. In addition the questions were also designed so that the answers were understood and were able to be summarized and reported. Overall construct validity posed a threat to the data obtained from the interviews, however because CTTÉI pre-tested the questions in their waste program BRIQ, this issue was controlled.

An additional limitation of this study was the lack of verbatim quotes obtained during data collection. Qualitative research methods, in particular interviewing, are often utilized for

their ability to obtain in-depth information about a program, event or process. One tool used to obtain this in-depth data comes from the ability to obtain verbatim quotes in the data collection process and then to utilize them in data reporting and the research findings. However, due to funding and time restraints of the research project it was determined that audio-taping and transcribing would not be used. Therefore the interviews were not audio-taped and verbatim quotes were not used in this study. It is important to note that utilizing quotes in research is argued to be important for several reasons including; presenting and supporting key findings and evidence, explaining complex processes and events, enhancing readability of the study (Corden and Sainsbury, 2006). It is theorized that using verbatim quotes would have assisted in fully supporting the findings of the study and would have been useful to explain the trends observed by the data. Using quotes to support the key findings of this study would have resulted in a more sound and complete study and would have assisted readers in understanding the ideas presented. For the benefits listed above, it is suggested that future studies on waste exchange programs and eco industrial parks would only benefit from the use of verbatim quotes in the data collection process. As realized by this study, it is critical to ensure time and funding is allocated to audio-taping and transcribing the interviews so that the benefits of this qualitative approach can be fully appreciated.

An additional limitation which exists with using both interviews and site visits as a form of methodology means that slight consistency issues may exist with the data collected. For example, it was explained that many companies provided information over the phone and did not request a site visit as others did. Reasons varied, but some preferred to have the facilitator visit to collect data and some felt that the visit was unnecessary. Implications of these varying methods means that the data is being collected a different time each time, and suggests that there could be

large variances in the data collected. For example, if the facilitator was able view the production process and view the wastes they may have been able to prompt for additional wastes and possible matches. A phone conversation on the other hand would not likely allow for this process and prompting to take place. Although, these differences in data collection may have occurred it becomes impossible to know which companies were affected and which possible exchanges opportunities were missed. However, this limitation discussion provides insight to future studies and data collection and suggests that in moving forward a more streamlined or consistent approach should be considered.

3.5 Minor Study Limitations

In addition to the limitations that were inherent to the methodology of this study, there were two additional limitations that existed and are separate from the data collection methods. These two limitations are discussed.

The first limitation of this study is the diverse expanse of the study area as well as the location of the study area. In its entirety, the Toronto EIP encompasses roughly 12,000 hectares and spans across 3 major cities and contains over 350 000 employees from several thousand varying companies. Clearly the Toronto Pearson EIPs size is quite cumbersome for one researcher (project facilitator) to study and therefore the assistance of a project manager and another part-time researcher (project facilitator) from the Toronto Conservation Authority was utilized. The additional facilitator assisted with contacting companies within the Toronto EIP and also assisted with attending site visits and imputing data into the database. CTTÉI in their review and recommendations noted that compared to their waste exchange BRIQ which only had 12 companies (40 exchanges identified) the large geographic expanse and area contributes to a much larger, weightier study. CTTÉI recommended that to start there should be a small

representation of companies from each of the 3 municipalities ensuring coverage of each area and also ensuring that manageable database for the two project facilitators.

The second limitation which existed for this study was the lack of funding and resources. This limitation warranted that all of the methods and sampling procedures be cost efficient and time efficient which somewhat limited the amount of data that could potentially be gathered for the study. For example, no incentives were available to offer to respondents and therefore might have reduced the response rate of the study. This limitation was somewhat solved with the partnership that the TRCA established with CTTÉI. With this partnership CTTÉI was able to provide a web-based forum and technical expertise at a relatively low cost. Roles and responsibilities were developed to help guide the working partnership and were as follows:

Table 2: Roles and Tasks of TRCA and CTTÉI (Emerald Group, 2010)

TRCA Roles and Tasks	CTTÉI Roles and Tasks
Ongoing identification and recruitment of companies with an interest in identifying by-product synergies. Collect and enter data collected from interested companies into CTTÉI's web-based analysis tool. Provide high-level screening of potential opportunities identified through CTTÉI's web-based analysis tool. Provide participating companies with a report on the synergies that are offered to them and provide assistance in identifying next steps. Facilitate meetings between interested businesses with potential matches, as well as involve CTTÉI as required for additional research assistance. Provide ongoing client support to facilitate by-product synergies between participating	Provide training and share its expertise on business engagement, data collection, communications and facilitation in relation to by-product synergies. Provide access to its web-based analysis tool in English for a period of two years. Provide initial data analysis on potential by-product synergies, categorizing them according to their feasibility: A" for "High potential", "B" for "Average potential" and "C" for "Low potential". Provide technical support and/or research and development as required on potential by-product synergies.

companies, limited to technical assistance and knowledge sharing.

Report and share the results of by-product synergies with broader Partners in Project Green community.

4.0 Study Results

4.1 Case Study: Toronto Pearson Eco Business Zone

Case studies are a strategy of inquiry in which the researcher explores a program, event, activity or process in depth and are bound by time and activity. Researchers collect detailed information using a variety of data collection procedures over a sustained period of time (Creswell, 2009). As Yin (1981) explains; the need to use case studies arises whenever an empirical inquiry must examine a contemporary phenomenon in its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. To understand how EIPs and waste exchanges can influence MSWM and Planning, their processes and activities must be explored in a real-life context over a sustained period of time. Therefore an existing EIP has been chosen as the case study. Based on the literature surrounding waste management systems and EIPs, it is clear that the relationship between MSWM and EIPs is not entirely clear and therefore argues that a case study could help determine a clearer picture in a real-life context. Thus choosing a purposeful case study that is representative of a typical EIP is necessary.

Benefits of using case studies are that they utilize concrete examples of how processes work, how research projects work (Creswell, 2009). The case study approach can test existing theories of knowledge and allows for close collaboration between the researcher and the participant. Although case studies present an array of benefits, there are some drawbacks to using this qualitative strategy. For example, case studies present an inability to focus on only few variables at a time, such as using controls to isolate for variables. In addition, case studies allow for the use of various data sources which allows for a holistic understanding of the phenomenon being studied. However, on this same note, authors Baxter and Jack (2008) argue that researchers often find themselves "lost" in the data as this type of approach requires intense amounts of data

management and organization. Importantly, it is noted that the use of a database to organize data is key in consolidating data effectively and can improve reliability of the data as it allows the researcher to track and organize data sources including key notes, documents and materials. Baxter and Jack argue that reporting a case study can be a difficult task for any researcher due to the complex nature of this approach. They argue that the researcher's role of reporting the findings in a concise manner, but also in a format that is easily understood by the reader can be extremely tedious and difficult. To understand how the process of a waste exchange might inform theories and concepts related to waste management and municipal planning, the case study approach was preferred. The Toronto Eco Industrial Park was chosen as the case study as it represents a newly transformed Canadian EIP and a fitting location to develop a waste exchange. It is critical to note that the Toronto Pearson EIP was not initially developed as an EIP but is slowly being retrofitted from an existing industrial area to an eco industrial park. The organizations long-term goal summarizes the change; "In the longer-term, Pearson Eco-Business Zone will evolve to become the first choice location for progressive companies with clean-tech operations and a desire to demonstrate eco-business leadership. These companies will be drawn by the existing regional assets, including Toronto Pearson; the success of existing businesses; and the knowledge infrastructure established by Partners in Project Green to assist companies in saving money and reducing their environmental impact" (GTAA, 2011). By attempting to establish a working waste exchange between the companies within the Toronto Pearson EIP, it is anticipated that a better understanding of the influences that EIPs and waste exchanges have on municipal solid waste planning will be understood. As Baxter and Jack suggest, to organize the data collected, this case study utilized a database to report all findings in a concise and organized manner. All results from the interviews were stored in the database resulting in a well organized

study and structured data reporting. The database was also easily accessible and easily managed allowing the researcher to avoid getting "lost" in the data.

4.2.1 The Toronto Pearson Eco Industrial Area

The Toronto Pearson EIP was created roughly a decade ago by a partnership between the Greater Toronto Airports Authority (GTAA) and the Toronto and Region Conservation Authority (TRCA). The partnership is known as, *Partners in Project Green* and they have named the EIP the *Pearson Eco-Business Zone.* The partnership began with a mutual understanding and a drive to restore, protect and enhance the region's natural resources which can trace roots to the founding of the conservation authorities in the late 1940s (GTAA, 2011). The TRCA works with industry leaders to promote green technology adoption as a way to reduce threats to the region's resources while building a sustainable economy. This area employs over 350,000 people the majority of whom work for medium sized (100-300 employees) manufacturing companies. There are several varying sectors of which make up the diverse companies within the Eco Park and include; Food and Beverage Manufacturing, Chemical and Plastics Manufacturing, General Manufacturing, Transportation and Warehousing, professional services, Construction and Infrastructure and lastly, Hospitality and accommodations.

As seen in Figures 9 and 10, the Project Green study area comprises 12,000 hectares in the Greater Toronto Area, a thousand of which is *Green Space* and includes the entire Toronto Pearson International Airport as well as portions of the Region of Peel, City of Toronto, City of Mississauga and City of Brampton. The study area also crosses three watersheds including the Etobicoke Creek, Mimico Creek and Humber River. The area falls under four municipal jurisdictions, including the Region of Peel, City of Toronto, City of Mississauga and the City of Brampton and consists primarily of employment areas bisected by a CN rail line and five major

highways (401, 407, 409, 410 and 427), with Toronto Pearson lying at the heart of the study area. The dominant existing green spaces include natural areas surrounding Mimico Creek and the Humber River in the east and Etobicoke Creek in the west. As seen in Figure 10, the Pearson Eco-Business Zone is unique compared to other large industrial areas, as it has a solid foundation of green space, with approximately 1,000 hectares of natural cover, with the potential for expansion to 1,230 hectares. Furthermore, roughly 180,000 employees within the Pearson Eco-Business Zone are within a 400 meter walk of green space, making it a valuable amenity for local businesses and their staff. Summarizing both its dimensions and amenities of the Toronto Person Eco Business Zone allows for a greater understanding of the use of it as the case study.

Figure 9: The Pearson Eco-Business Zone (GTAA, 2011)

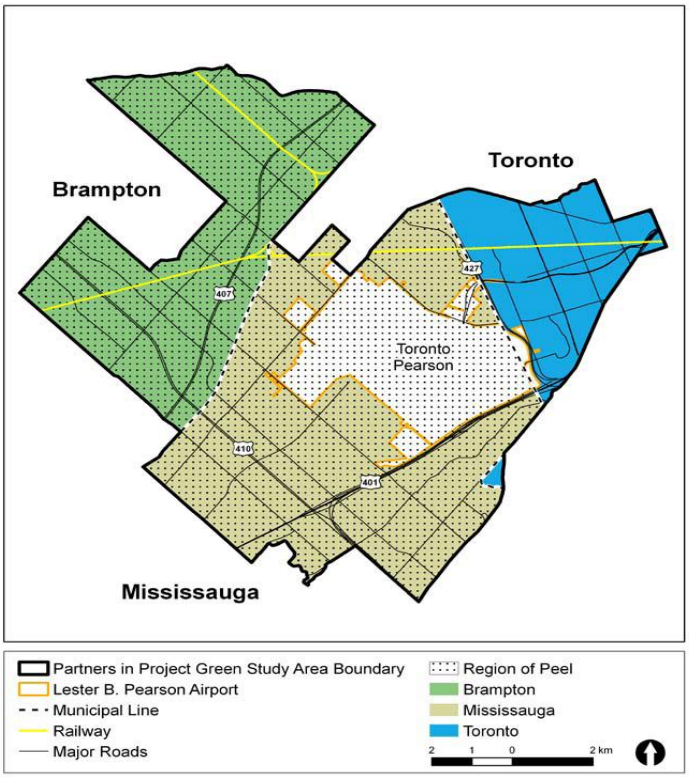
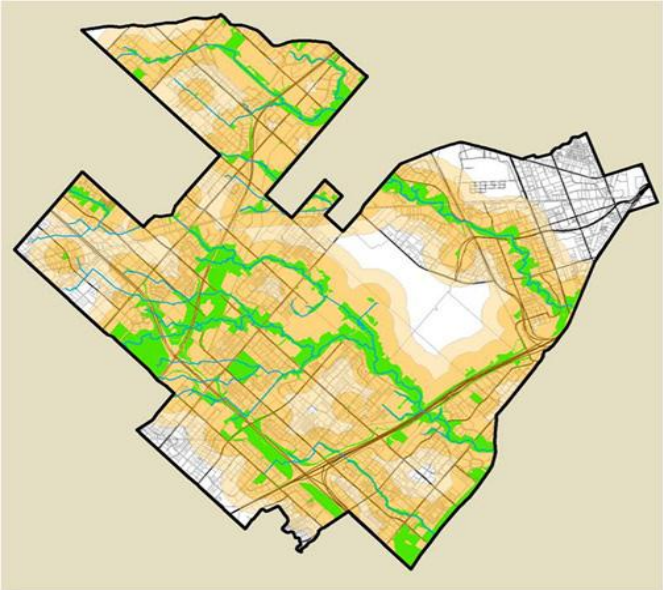


Figure 10: The Pearson Eco-Business Zone Green Space (GTAA, 2011)



4.2.2 PPG Company Database

Partners in Project Green initiated their database with a commercial directory of businesses in the outlined geographic area described above. Through direct calling, PPG expanded and consolidated the list and currently have reached a total of roughly 12 500 companies in their database list since beginning in 2008. In building their initial commercial contact list, the list was built out as companies were contacted by their industry or trade organizations to sign up for programming. Within the registration process, businesses have the opportunity to become a PPG *Participant*, a PPG *Partner* or a PPG *Ambassador*. PPG claims that companies who designate and register for one of these titles allows them to self-identify and manage sustainability solutions as tailored to the company needs. As a *Participant* companies can register at no charge and can participate selectively in workshops and networking events. As

a *Partner or Ambassador*, companies can sign up for a cost depending on size of organization (See Table 2) and can create a business profile and start a relationship with a Program Advisor. This Program Advisor will actively seek opportunities for eco-business innovation in the Person Eco-Business Zone. In addition, companies who become PPG *Partners* will see the following benefits:

- Program Discounts – preferred rates for training opportunities and green products and services;
- Sustainability Support – Personalized assistance in navigating and gaining access to PPG programming;
- Recognition – Opportunity to share sustainability success stories with clients and peers through case studies and news stories;
- Network – Ability to contact companies in the Person Eco-Business Zone Directory;
- Drive Sales – Create a Green Vendor profile to connect to clients looking for sustainable products and services.

Companies who become PPG *Ambassadors* are businesses who are committed to a long-term relationship and participation with Partners in Project Green. They play a leadership role in promoting eco-business innovation in the Person Eco-business Zone. *Ambassadors* receive the above list of benefits and the additional following list:

- Dedicated Business Advisory services – Personalized support to identify and coordinate advances company specific eco-business opportunities.
- Media Exposure – Exclusive opportunities to be highlighted in Partners in Project Green media stories.
- Web Domain- Create exclusive Partners in Project Green web domain.
- Community of Excellence – Access to Business Ambassador learning and leadership roundtables.

Table 2 below highlights the annual fees to become a PPG Partner or Ambassador. However, these fees are waived if the company falls into the following category:

- Participation on Steering Committee and Project Teams.
- Sponsorship of Partners in Project Green events and programming that exceed the subscription cost.
- Acting as a resource for referrals or by opening facilities for site tours.

Table 3: PPG Annual Membership Costs (GTAA, 2011)

Employee Number	0-10	11-50	51-100	101-500	500+
Cost	$50	$100	$150	$300	$400

4.2.3 Case Study Sector Summary

To identify companies to involve in the outreach and possible waste exchange program, a significant task of analyzing the companies within the Person Business Zone was necessary. Within the Pearson Zone there are approximately over 12 500 established businesses that fall into the outlined boundaries. A breakdown of the number of businesses within each municipality in the Pearson Eco-Business Zone is highlighted in Table 3.

Table 4: Breakdown of Businesses in the Pearson Eco-Business Zone (GTAA, 2011)

City	Estimated # Jobs	Average Business Size	Total # Businesses
Brampton	116,000	26	4,665
Mississauga	186,000	30	6,369
Toronto	53,000	37	1,466
Total	355,000	29	12,500

The business typology in the Pearson Eco-Business Zone is diverse and includes everything from service and accommodation operations, to the manufacturing and logistics sectors. The largest sub-sectors are transportation and logistics, automotive supply chain, plastics and food processing. Figures 7 and 8 provide a general graphic breakdown of each of the sectors.

Figure 11: Business Size Distribution in the Pearson Eco-Business Zone (GTAA, 2011)

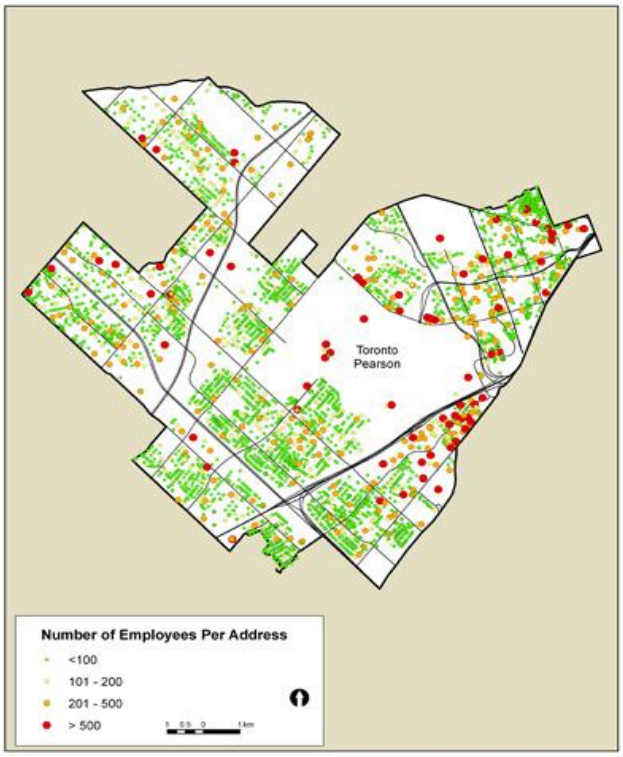
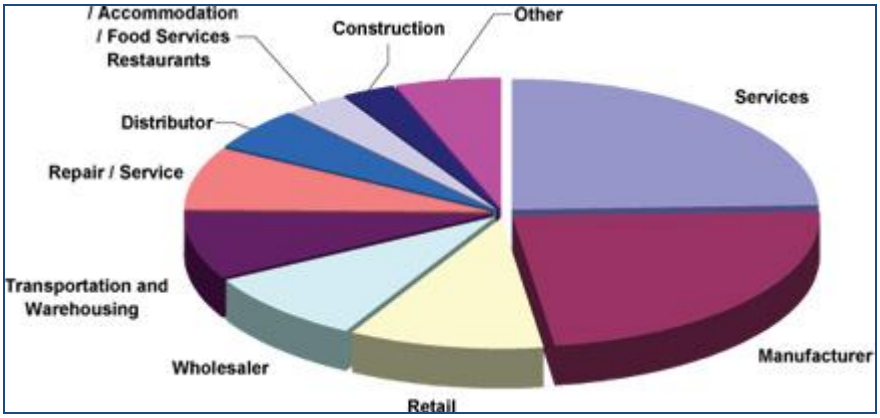


Figure 12: Business Sector Breakdown in the Pearson Eco-Business Zone (GTAA, 2011)



4.2.4 Toronto Pearson Eco-Business Zone: A Waste Exchange Opportunity Identified

In 2010, PPG retained The Emerald Group consulting firm to conduct a report outlining the feasibility of establishing a Materials exchange program within the Pearson Eco-Business Zone. The report concluded that given adequate funding and staffing, a materials exchange could be a successful project. That report identified several particular findings as being most critical for the start up of the project. They include:

- Areas with large manufacturers, packagers and distributors of goods are considered ideal for the operation of an exchange. The ideal catchment area should have a high concentration and variety of manufacturers, import/exporters, packagers and distributors from different industry sectors. In practice, industries of any sector generating large quantities of simple raw materials or finished goods are ideal.
- A dedicated and diverse Technical Advisory Committee was identified as an important component of promoting the service and facilitating exchanges.
- Research clearly indicates that passive websites alone are not sufficient for a materials exchange to be successful. A staff compliment of two full time operators (i.e., an exchange manager and an outreach worker) supported by an administrative assistant was found to be a workable model for launching an exchange with the number of outreach workers growing as warranted.
- Approximately six months are required to organize and launch a material exchange or similar initiative during which time the number of exchanges will not be significant.
- Active involvement of stakeholders and sponsors is considered critical to promoting and supporting the efforts of exchange services and resource reutilization initiatives.
- Ongoing and aggressive outreach remains a key component of an effective marketing strategy for a materials exchange. Notwithstanding this comment, effective web sites are now considered equally important to successful service delivery and profile development.

Based on the conclusion that a dedicated technical team was needed and that funding was a critical piece to establishing an exchange, the TRCA actively searched for a possible partnership to assist with establishing a materials waste exchange. The TRCA and PPG were able to secure a partnership with the Quebec-based College known as CTTÉI*: Centre de transfert technologique en ecologie industrielle*, whose expertise and research centers mainly around industrial ecology. Focused on the environment and sustainable development, in 1999 the Centre was founded and was certified three years later by the Ministère de l'Éducation du Loisir et du Sport du Quebec as a college centre for technology transfer. The CTTÉI then joined the Réseau Trans-tech, a

province-wide network of applied research centers. CTTÉI aims to enhance the performances of businesses and communities in Quebec through research and development into innovative approaches and technologies in industrial ecology focused on waste reclamation, green products and new industrial synergies. The CTTÉI therefore seeks to play a leadership role in Quebec by promoting industrial ecology, contributing to human resource training in the field and coordinating and leading industrial, inorganic and mixed waste reclamation initiatives. CTTÉI focus on several specific niches and areas of expertise including:

- Waste reclamation (metallurgical, organic, electronic)
- Environmentally-friendly materials
- GHG
- Synergies
- Quebec Industrial Waste Exchange (BRIQ)
- Green chemistry
- Waste sorting and management technologies

Of the niches of expertise listed above, the *Quebec Industrial Waste Exchange (BRIQ) already* highlighted in the Literature Review under the Canadian waste exchange section, is particularly important to this study as this exchange program was used as the basis for the training and expertise knowledge in creating the Toronto Pearson by-product exchange program. In addition, the computer database used to create waste matches for the Quebec industrial exchange was utilized to create synergy waste matches between companies in the Toronto EIP.

4.2.5 PPG Sector Breakdown

To begin creating an outreach list of companies to include in the study, a breakdown of the PPG company database totaling roughly 12 500 was analyzed and developed into a potential contact list. A report on this contact list was created and sent to CTTÉI for further analysis and study recommendations. Findings of this report are summarized and identify how the initial contact list was created for the study.

The 12 500 businesses existing in the Pearson Eco Business Zone was clearly a large undertaking for creating an initial contact list. Therefore, it was decided that focus would be placed on certain specific sectors only. From the sectors identified in Figure 12, businesses were eliminated that did not fall into; General Manufacturing, Food and Beverage Manufacturing, Transportation, or Construction and Infrastructure. This process reduced the overall total of 12, 000 companies into approximately half totaling 6,288. The 6,288 companies were then sorted by size of company and organized by total employees. Figure 14 below demonstrates the breakdown of sizes of companies and the total for each sector. Companies were sorted based on if they were a certified *PPG Ambassador* or *PPG Partner* and if they had an Environmental Management Strategy (EMS) or a Corporate Sustainability Report (CSR). These initial sorts were selected because it was hypothesized that companies already involved in environmental and PPG related programs would have a higher propensity to engage in the waste exchange project. Therefore, the project focus on three initial screens as demonstrated including:

- Size by Employees
- PPG Partner / Ambassador
- EMS / CSR Present

Once this list of companies was completed it was sent to CTTÉI for recommendations. CTTÉI major recommendation was that any companies in the Transportation Sector be removed due to the fact that this sector generally doe not generate significant amounts of waste synergies and because recycling markets already exist for most of the items. As recommended by CTTÉI all transportation companies were removed from the list. From this screen there were a remaining total of 485 companies as highlighted in Table 4.

Table 5: Finalized Outreach List and Database Breakdown Screens

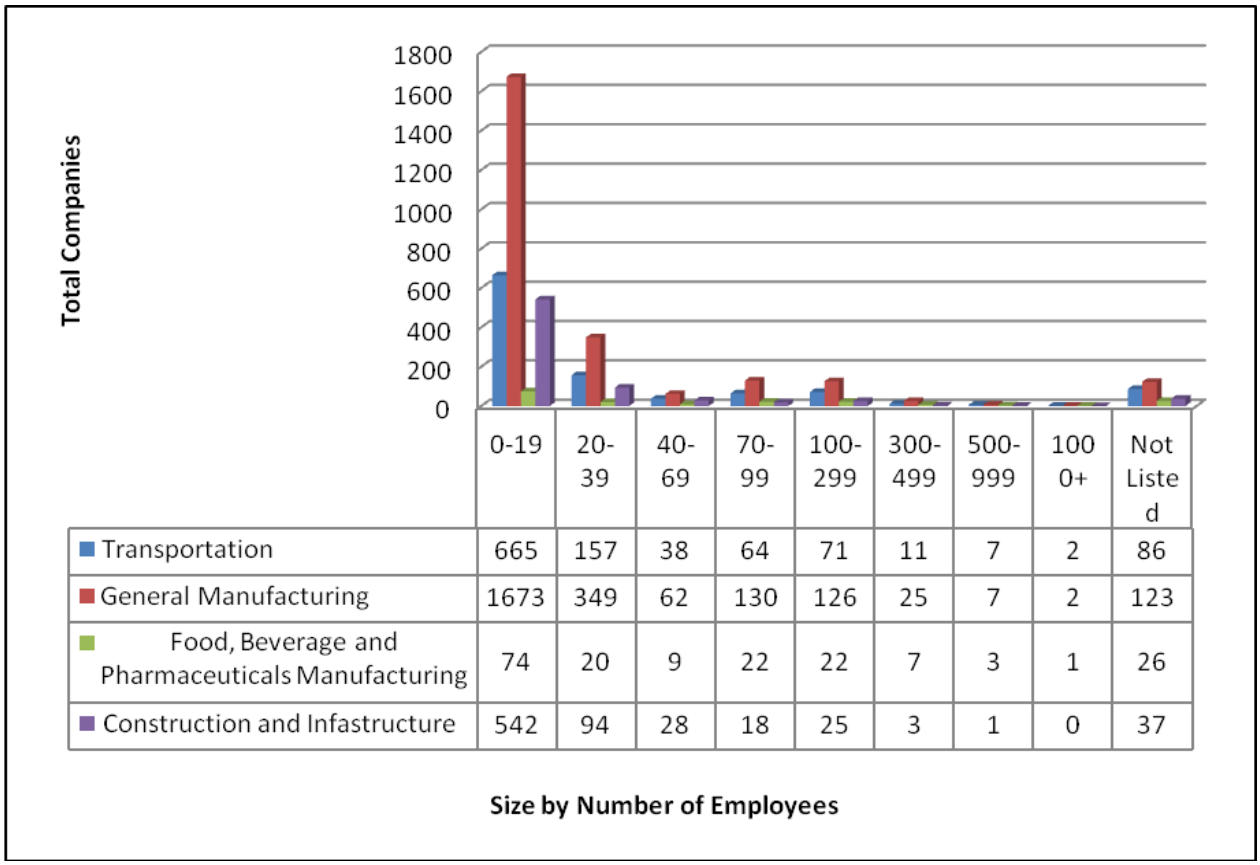
Screen	Total Companies
100 + Employees	213
PPG Ambassador/Partner	148
EMS/CSR	124
Total	**485**

It is important to note that some of these companies were counted more than once in the total as they fell into more than one of the categories above. The total number of companies which were listed more than once totaled 102 companies. Therefore 102 companies were subtracted from the initial screen leaving roughly 383 companies to contact. Additionally the companies were sorted based on geographical location of either, Toronto (66), Brampton (187) or Mississauga (232). This initial list was then reviewed by the project manager who shorted the list based on his expertise and interaction with the companies themselves. Companies were removed that;

- Did not fit the "profile" meaning what they manufactured would not be able to be exchanged, and;
- Companies who had duplicate plants/locations on the list.

These two additional sorts resulted in a total of 337 companies amongst the 3 municipalities Toronto (39), Brampton (132) and Mississauga (166).

Figure 13: Size of Company by total number of Employees for each Sector



	0-19	20-39	40-69	70-99	100-299	300-499	500-999	1000+	Not Listed
Transportation	665	157	38	64	71	11	7	2	86
General Manufacturing	1673	349	62	130	126	25	7	2	123
Food, Beverage and Pharmaceuticals Manufacturing	74	20	9	22	22	7	3	1	26
Construction and Infastructure	542	94	28	18	25	3	1	0	37

(Data Source: GTAA, 2011)

4.3 Data Collection Results

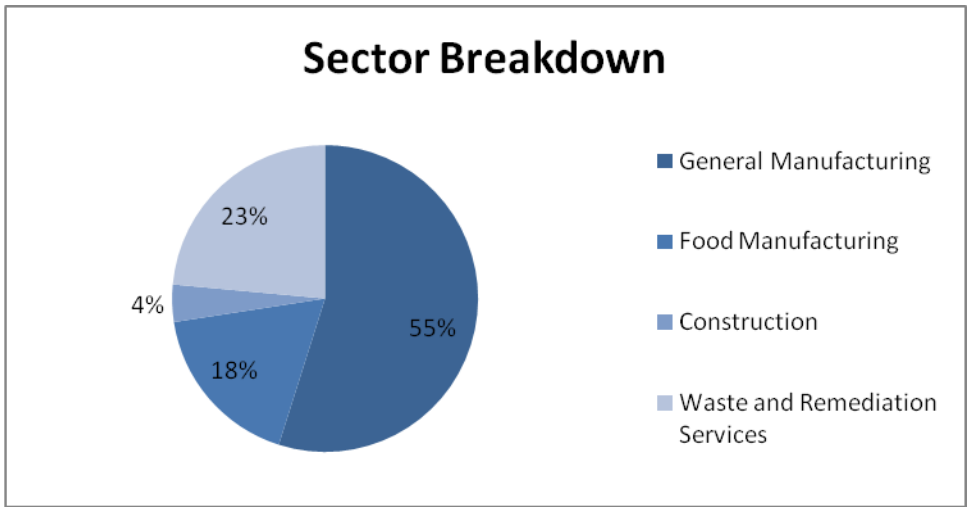
A total of 337 companies were contacted. Of the 337 contacted there were 39 companies were contacted in Toronto, 132 contacted in Brampton and 166 contacted in Mississauga. A total of 117 companies responded either directly to the email or phone the first time. This list includes people who responded with initial interest in the project but did not give data. Some industries would ask to be involved in the project and would request the data collection sheet or would request a phone call, but would not fill out the sheet they were sent and would not respond to a follow-up call or email. Of those 117 companies, data was imputed into the database for a total

of 51 companies. The coded list of companies contacted can be viewed in Appendix B. The following sections below describe the results of the data collection of the 51 companies who responded with data.

Sector Breakdown

Figure 14 below highlighted the general breakdown of the 51 companies who submitted data. The majority of companies were General Manufacturers. This majority is expected given that General Manufacturing makes up the majority of the companies in the entire PPG database. Following were companies in the Waste and Remediation Services and Food Manufacturing. Construction made up the smallest portion of companies. The companies which were identified as Waste and Remediation Services in this breakdown originally fell into the General Manufacturing Sector in the initial breakdown discussed in Section 3.2. These companies are in the business of producing products purely from recycled material or are in the business of recycling wastes and preparing them for re-use. For data analysis purposes these companies have been taken out of the General Manufacturing category and sorted separately. The implications and reasoning for sorting these companies separately will be discussed further in the discussion section of this study.

Figure 14: Sector Breakdown of Company Data



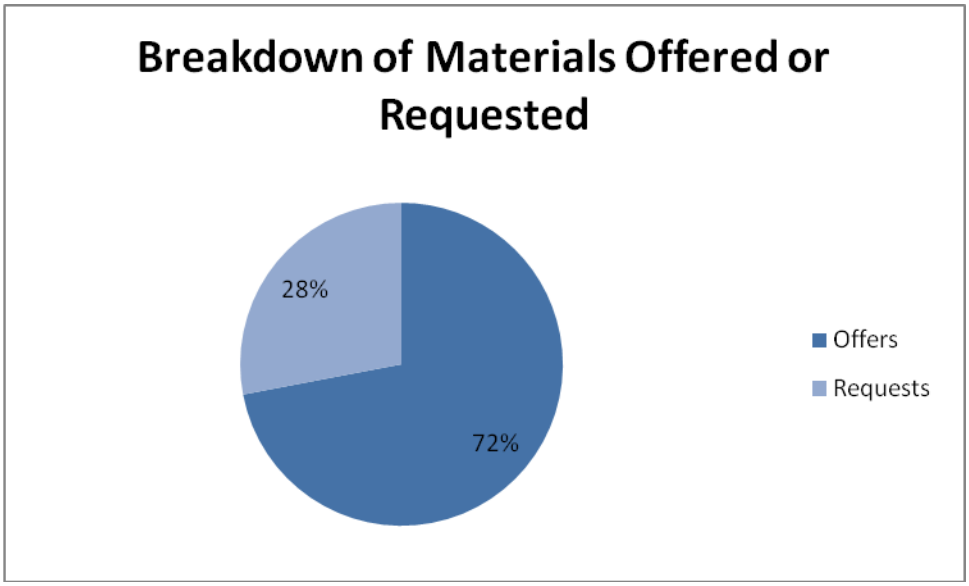
(Data Source: Synergie Quebec 2012)

Waste Materials

The main portion of the data collection involved obtaining information about the "inputs" and "outputs" of the companies. The "inputs" are the products going into the facility for production and the "outputs" are the wastes leaving the facility post production. When this data was submitted into the database the inputs and outputs were classified as "Offers" (outputs) and "Requests" (inputs). This classification was done because it was important for companies to understand that their outgoing products could be seen as a resource or an input and that other companies easily associate wastes as a possible input or resource. Figure 15 below demonstrates that the majority of wastes were offered and not requested. Although only 51 companies offered data, there were numerous offers and requests given for each company ranging anywhere from 1 offer or request per company to 18 per company. For the 51 companies, there were a total of 180 offers given and 70 requests given making a total of 250 offers and requests. Figure 15

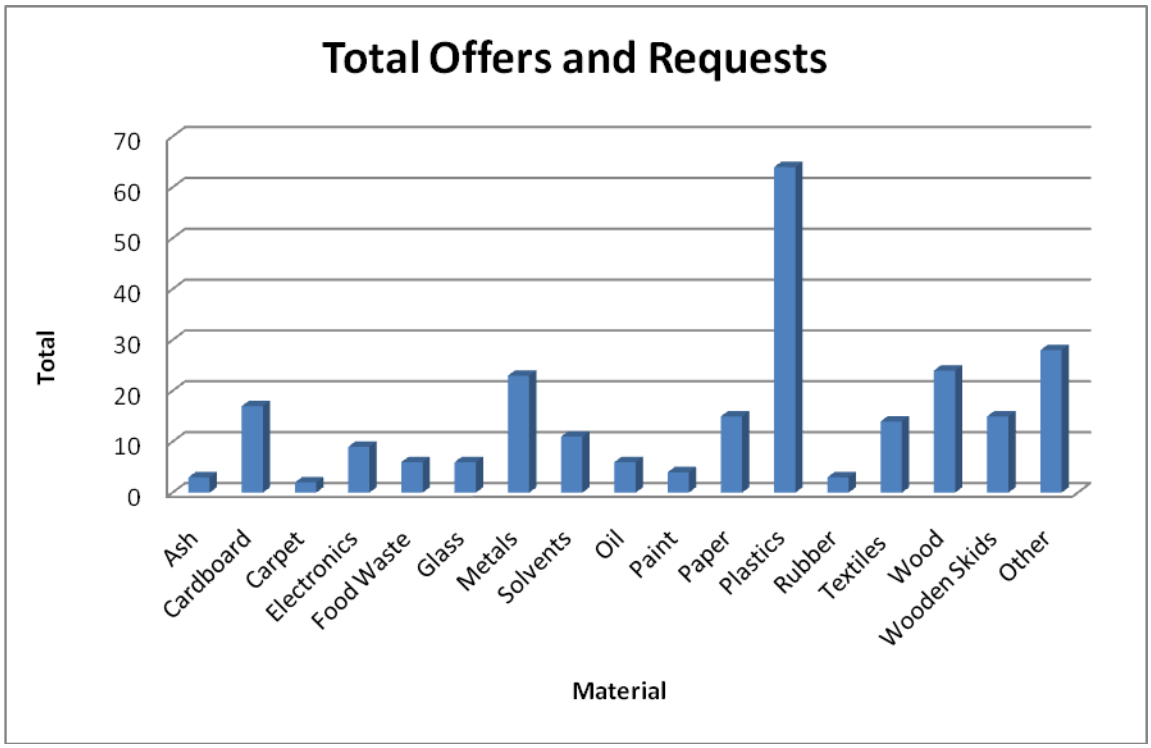
demonstrates the material classification breakdown of the 250 total offers and requests. Figure 16 and Figure 17 breakout Plastics and Metals which were the top two materials offered and requested. It is important to break these materials out as there are numerous types of plastics and metals. It is key to understand the main types of materials made available for the waste exchange and the implications that these materials may have on the outcome of a successful exchange.

Figure 15: Total Materials Offered and Requested



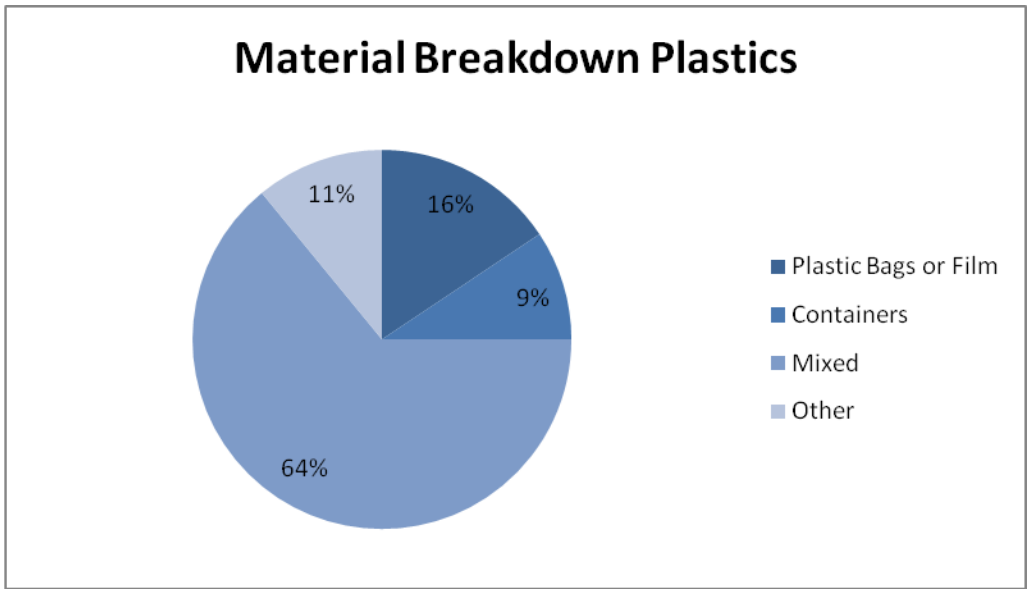
(Data Source: Synergie Quebec 2012)

Figure 16: Total Material Offers and Requests



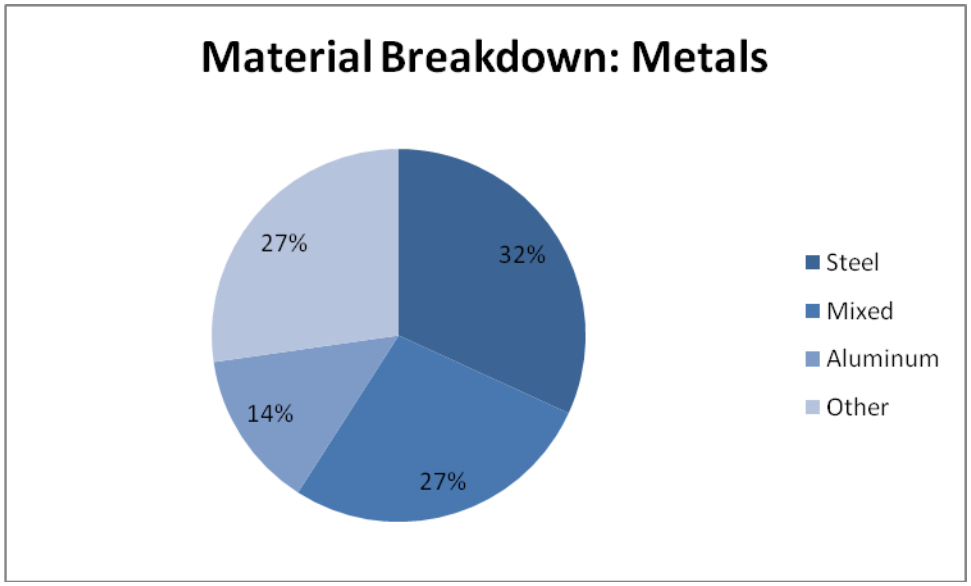
(Data Source: Synergie Quebec 2012)

Figure 17: Breakdown of the various types of Plastics offered and requested



(Data Source: Synergie Quebec 2012)

Figure 18: Breakdown of the various types of Metals offered and requested



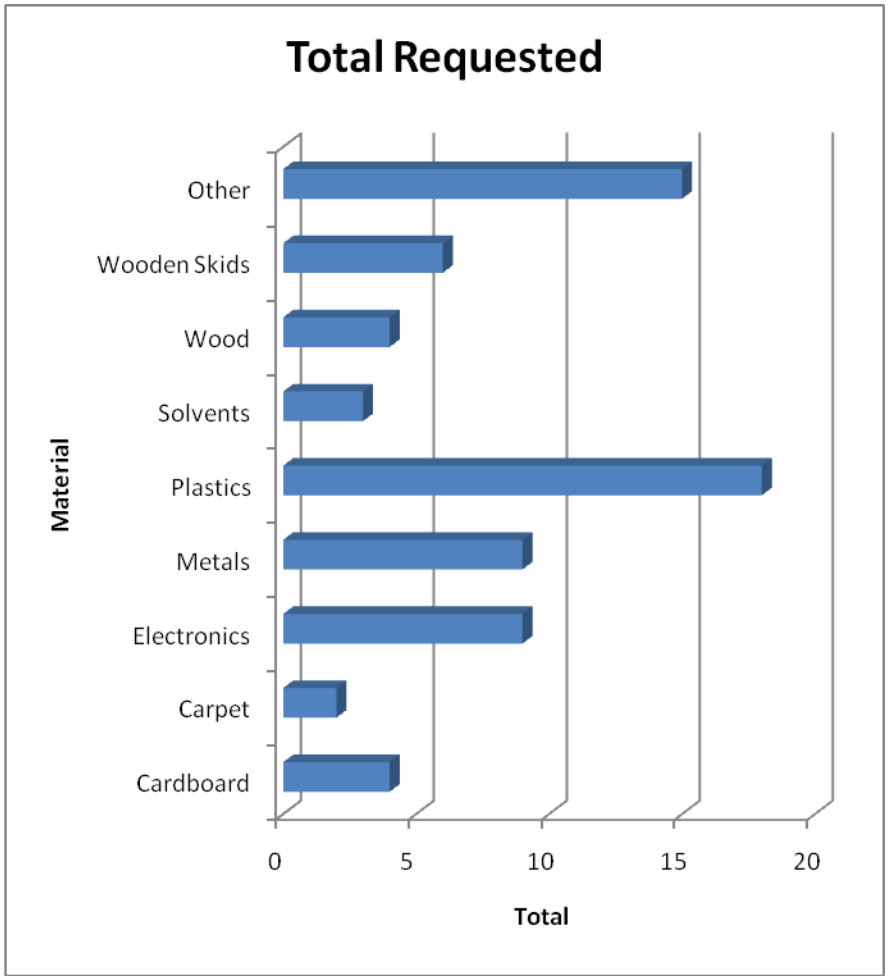
(Data Source: Synergie Quebec 2012)

Figure 19 and Figure 20 breakout the total offers and requests and show the material make-up of the two categories separately. In both categories, Plastic is still makes up the majority of wastes. However, differences arise looking at the other top materials. For example, the second highest material offered is wood and for the requests it is "other" materials. The third highest material for offers was paper and textiles and for the request category they were metals and electronics.

Figure 19: Breakout of total Materials offered

(Data Source: Synergie Quebec 2012)

Figure 20: Breakout of total Materials requested

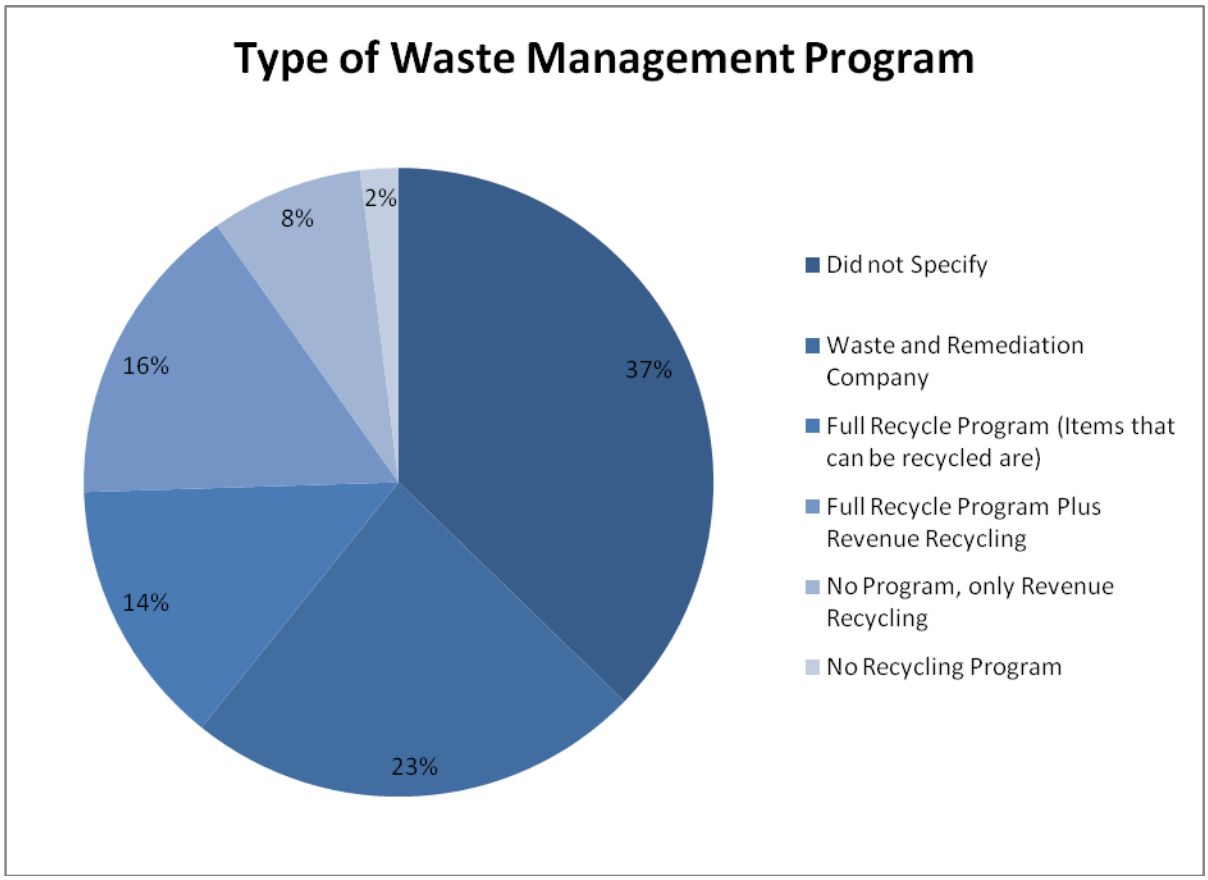


(Data Source: Synergie Quebec 2012)

Figure 21 identifies the general waste program which each of the 51 companies described. The majority of companies did not specify their waste program. Waste and Remediation companies made up the next highest majority. A company was classified as having a "Full Recycle program" if the company recycled all of the materials that could be (according to Ontario Regulations) and then landfilled the rest. An example of this would be: recycle plastic and metal,

compost food and kitchen grease and send plastic film wrap to landfill. Revenue Recycling meant that companies sell products to companies or recycling manufactures for money in return. No recycling program means that the company sends all waste to landfill.

Figure 21: Type of Waste Management Program provided at each Company



(Data Source: Synergie Quebec 2012)

4.4 Waste Matches

The total number of waste matches created by the database was 112. In addition there were 13 matches manually created bringing the total matches to 124. As demonstrated, the Auto Match feature if used correctly or as it was intended to would have sent an email out to each of the companies explaining that a match was made. Companies were then to visit the site and contact one another. As a result of the translation delays this feature was never carried out. Some of the 13 matches were not a success because some did not work out once followed through for reasons discussed below or the company contacts never responded to the email or follow up call.

4.5.1 Actual and Successful Exchanges

The list of waste matches was sorted into 4 major categories. The categories are described as follows;

- No Response from one or both Companies
- Response and unsuccessful match (Due to Various Factors including: Size, Quantity, Poor Description)
- Response and Successful Exchange
- Response and Working on Developing a Successful Exchange

The majority, 91 out of 124 waste matches have not been a success due to lack of response from one or both companies. A total of 13 out of the 124 matches are currently being developed. This category includes companies who have sent emails to meet or discuss possible exchanges, but have not finalized the exchange yet. Only 1 exchange out of the total (124) has been completely successful and includes the exchange of approximately 80 skids. A total of 19 (out of 124) exchanges have been attempted but were not successful. In these 19 scenarios the match was unsuccessful because the description of the product being offered did not match exactly what the

demand was. The results of this study so far show only demonstrate one active exchange. However, there are 13 exchanges being developed suggesting that over time these could become working exchanges. In addition, there were 19 attempted exchanges which did not work out due to description match issues with the waste offers and demands. Although none of these matches worked completely, the steps to connect companies and establish a working relationship between the companies was slightly successful. The discussion portion of this paper in the following sections further analyzes the results briefly highlighted and discusses the potential for further success with the exchanges.

5.0 Discussion

5.1 Initial Data Trends Discussion

Before looking at the broader impact of the data results there are some initial trends in the data which should be discussed briefly. These trends will be re-visited further in this section.

Trend # 1: The majority of companies are General Manufacturing followed by Waste and Remediation.

It was expected that the majority of companies who responded to the data questions would be general manufacturing because this sector makes up the majority of the PPG database. The waste and remediation companies composed the second highest majority because they are in the business of dealing with wastes. They would likely view this exchange as an opportunity to inform and educate companies on what to do with some of their wastes and making themselves available for increased business. They may also view the exchange as an opportunity to highlight or advertise products they produce with recycled inputs.

Trend #2: Majority of companies offered wastes instead of requesting wastes

This trend could mean several possible things. First, this could be indicative of the mindset of the majority of these companies. This mindset is one that people do not think of waste as a resource and are not likely to think of their waste as a potential input. Secondly, this trend could be that companies do not want to pay to get rid of their waste and view this as an opportunity to lower their waste removal costs. Third companies may think that taking in waste will mean extra costs and time to prepare it for production. On a similar note, companies may think that if they request a waste, they may be responsible for transporting it which would mean additional costs and time. Lastly, the majority of companies requesting to take in waste were Waste and Remediation companies and suggests that because these companies make up a small

portion of the database the amount of waste requested would be much smaller than the amount offered.

Trend # 3: Plastics were offered and requested the most followed by "Other" Materials, Metals, Wood and Cardboard.

For both offers and requests plastics were the top material. There could be several reasons for this trend. One, the manufacturing practices by the companies in the database could use plastic as the primary input in their production. Its use as a primary material in production could be because it is much cheaper than alternatives such as wood and metal. Secondly, the high instances of plastic could suggest that it is difficult to manage in the waste stream meaning it is non recyclable or expensive to recycle. Last, companies in the waste and remediation sector may utilize plastic to produce new materials therefore making it a high item for requests. After "Other" materials category, Metals followed as the third highest majority material. The main reason for these materials being the top three is likely because there is a large recycling market for this already where revenue can be made. Companies likely requested and offered materials such as metal because they are aware they can make money off of it by selling it to various markets. Cardboard was the next highest material offered and requested and is likely due to the fact that a large majority of materials are shipped and transported in cardboard. For example, food manufacturing companies likely receive their raw products in cardboard and ship out final products in cardboard just as many other companies similarly do. Cardboard likely makes up a large percentage of the requests and offers simply because it is a popular, cheap material likely used by most companies in some form.

Trend #4: Majority of Plastic Waste is unidentified Mixed Plastics

The majority of Plastics identified were "Mixed Plastics" which suggests that companies use varying types of plastic in their production. Some companies were very specific with the type of plastic stating plastic such as; polystyrene, polyvinyl chloride (PVC) or polyester. This trend may suggest that plastics are the material most used in production numerous reasons. However, this trend also suggests that companies may not be as familiar with the wastes they create either because they do not have to (they do not recycle the plastic so they do not need to know its make-up) or because they simply have so much varying plastic waste they did not want to spend time providing the specific data for it. As mentioned, the "Mixed" plastics were composed of many polymer plastics some of which represent hard to recycle plastics. For example, plastics like polyethylene terephthalate (PETE) are more easily recycled than Polyvinyl chloride (PVC) due to the chemical make-up of the plastics. This suggests that companies may not have a recycler willing to take the "mixed" plastics as this may contain more of the "hard to recycle" items. In addition, if the "mixed" plastics are truly a combination of various types of plastics mixed together it may be a costly procedure to separate and prepare for recycling. This may represent another reason why these plastics make up the majority of the offers and requests.

Trend #5: Top Materials differed between the Offers category and the Requests Category

The top materials in the Offers category proved to be very different than the top materials in the Request Category. The top materials for Offers were Wood and Paper. The top materials for Requests were Plastics followed by a grouping classified as "Other". The materials in the "Other" category included items such as: Cigarette Waste, Clothing, Coal, Gypsum, Junk, Coffee Disks (Tassimo, Nespresso), Office Furniture, Roofing Materials, Salt and Sand Road Paving Materials, Writing Instruments and General Waste. In this "Other" Category there was only one

of these particular items requested making it a unique product which could not be classified with other materials. There are some possible explanations for these trends. First, it is possible that wood and paper are materials which most companies use in their production, despite the sector or type of production and is a result of the high number of these materials being offered. It is also possible that there maybe a smaller revenue market for wood and paper. Companies may not take the time to sell or recycle it as they may not make as much money off of these products compared to metals for example. If this is the case, companies may choose to landfill rather than recycle. As for the requests, the "other" category is made up of single item requests. For example, one company requested Coal, another requested Roofing Materials, another company requested Sand and Salt. These materials were ones which were very unique and were only requested once. The low frequency of the materials in the "Other" category made exchanges of these materials unachievable. This trend suggests that possibly there are some companies specializing in very unique and specialized recycling or have a particular use for a product. For example, the company who requested Sand Salt could be looking for these products as a de-icer in the winter months and really have no use for the material in their production.

Metals and Electronics were the following top requests. This is expected as many of the companies making requests for waste are in the waste and remediation services sector. Many of these companies take both metals and wastes and recycle them down into other products or for raw materials for which they get revenue from. Generally, metal and the metal extracted from electronics are worth the most money and suggest that companies who are revenue driven will want these wastes as they result in direct profits.

Trend #6: Most companies had some form of Waste Management system involving Recycling

Part of the interview asked companies to report on how the wastes in their company are managed. The majority of companies did not specify how their waste was managed. However, of companies that specified, the majority at 61% had some form of waste management system. There are two possible explanations for this. One, companies may not feel it is necessary due to the fact that for an exchange to be successful, all that is needed is information regarding the wastes. Secondly, companies may choose not to specify if they feel their waste management system is not operating as it should be or if they do not have one. It was expected that most companies would have some sort of recycling system in place as it is mandated by the Ministry of Ontario. In addition, a number of companies are in the business of Waste and Remediation and therefore their business relies on recycling systems. It is obvious that revenue recycling is a practice which a lot of companies partake in. There could be several reasons for this. One, a company may have products which can be easily sold for revenue such as metal. However, some companies may want to sell products for revenue, but do not have any outputs in their production which can be sold. It is also evident that some companies only recycle things for revenue.

5.2 Communication and Participation

It is obvious that the major barrier to success of this project – at least so far, is a lack of communication between companies and the facilitators. There could be several reasons for this. First companies may not simply have time. When the letter was first distributed it is possible that the program was of interest to the company and so they responded initially with data. It is possible that over time the company has become involved in other projects or associations for which they have chosen to focus their time on. A company may also not have time due to a spike

in product production and it may be possible that the company contact is first and foremost involved for tasks as they relate to product production only. The company could also be at the end or near the end of one of its financial quarters suggesting busy time for sales and administration and having little to no staff to focus on other projects. Additionally, the assigned person to the project may no longer work at that company or may have switched roles in the company. If this is the case it is possible that no one else in the company knows about this project and may have failed to "hand-off" the project to another person or the person filling their role. For instance, one company who was apart of the study had requested large amounts of varying materials including mostly wood and metal. This company contact was involved during the launch of the product providing data and numerous waste requests. However, it seems that this company's interest in the project disappeared resulting in many of the 91 "unresponsive" waste exchanges. This company was matched a total of 54 times for the request of various materials contributing over half of the total unsuccessful matches This also suggests that the data is in fact is slightly skewed in the sense that one company is a major contributor to the failure of the working exchanges and that although the numbers show a high non-response rate; it is not necessarily the actual trend. However, without a direct response from both companies the reasons for an unsuccessful exchange cannot be truly known, only hypothesized. It is also possible that the non-response will become a response over time and that the company contact has yet to respond to any email or phone call. It is possible that as this project continues on that the response could occur and result in a successful exchange.

It is obvious that there are numerous communication and response factors that have so far affected the success of the potential 124 exchanges. These results also suggest that an alternate communication strategy maybe required. For example, the communication strategy was modeled

on the feedback and experience given from CTTÉI's BRIQ project of which only involved 12 companies initially. This number is much smaller than the 337 companies that were part of the initial outreach for this project. This suggests that a more intense and varying communication and project strategy should have been considered. For instance, CTTÉI suggested that phone calls and site visits were most successful in gaining response rates and this was the main communication outreach used for this project. In addition, CTTÉI had one full-time, dedicated employee to manage and facilitate their project BRIQ. Further, CTTÉI advocated that good results were a product of a large time investment of their one employee. For the Toronto Pearson by-product exchange project there was only one full-time facilitator and one part-time facilitator suggesting that if compared to CTTÉI's project BRIQ there was not nearly enough people. Using the ratio of 1 person for every 12 companies the PPG By-Product project should have acquired approximately 28 full-time staff resources. Given the limited resources and funding, 28 people were not a possible acquisition for this project. However, if for example, the project were able to acquire more full-time facilitators who were assigned to a particular set of companies, this would allow for more intense focus and communication between the companies also making site visits more plausible and more frequent. Without testing these measures it becomes impossible to accurately know if additional project facilitators would have lead to higher success in communication and response. However, given the success of the CTTÉI BRIQ project it is plausible to say it would be a benefit over a disadvantage.

Another issue with communication was a lack of data reporting by company contacts. For example, a total of 37% of companies failed to report on their current waste management practices. It is hypothesized that this lack of data reporting may be due to the fact that companies do not have proper waste management systems in place and are at risk of being fined by the

Ministry of Environment. It is also possible that company contacts did not feel it necessary to report on this as it would not have direct effect on them participating or benefiting from the exchange. It could also be possible that the contact simply does not know the system in place and did not respond for this reason. Despite the reasons, it is clear that this question represents a poor communication dynamics between the company contact and the facilitator. Understanding the waste management systems is important to understand the waste management needs of the companies and how they may benefit from the exchange. In moving forward with this study, it is clear that better communication techniques are needed to gain a more complete data set.

5.3 Movement in the Waste Hierarchy

One issue discovered in the course of this research and requires some discussion is the general trend of companies seeming to be fixed within a certain level in the waste hierarchy. Referring to back to Figure 3, the waste hierarchy is composed of 5 levels. As one moves up in the hierarchy, one becomes more environmentally sustainable. It was clear that with the companies actively involved in the development of this waste exchange program were mostly involved with the recycling level of the hierarchy which posed some issues to broadening the study. Essentially the 24% of companies who already had a place for their wastes did not see the need or potential to diverge away from recycling. In essence, no company felt the need or desire to move up the waste hierarchy and find alternates for their waste already being recycled. This lack of movement meant however, that this project was only able to capture a very small proportion of the actual waste stream flowing out of these companies and only able to capture the some of waste exchange possibilities. There are three hypothesized reasons for why this trend is occurring.

First and foremost it seemed that one of the biggest issues with gaining company support is the fact that this project is competing with an already established recycling market. For example, a total of 24% of the companies who provided data were already involved in some form of revenue recycling meaning that they sell a portion or all of their output materials for revenue. 16% of that 24% partake in both non-revenue recycling and revenue recycling and numerous companies within this 16% identified that they had various wastes as a part of their production process, but only some were offered to be apart of the exchange project. In many instances companies would have scrap metal or skids as a waste but already had an agreement with a company who would pay them to transport these waste away and have them recycled. In every instance where a company had an agreement with an external company to haul their waste away they did not want to offer this waste to the exchange program unless they could receive a better revenue alternative. It is obvious that companies only seemed motivated to be apart of the project if there was a monetary benefit (they saved or made money). In the cases where companies were being paid for their waste it seemed they wanted to continue with that agreement and were not willing to offer that waste as a part of the data collected unless they could get more money with the exchange. This trend is particularly evident when looking at the total materials offered to the exchange. For example, plastics were the number one product requested followed by metals and electronics. The plastics were heavily requested as there were several companies in the waste and remediation company sectors and general manufacturing sectors which utilized recycled plastic to make a variety of products. Metals were also heavily requested as metal can be sold for a higher return. On the same note, electronics were also heavily requested as many waste and remediation companies extract metal from the electronics for revenue. In addition, several companies (8%) admitted to only participating in revenue

recycling which suggests that there are wastes leaving the company that are going straight to landfill. For example, if a company only produces sheet metal and they have excess metal which they sell for revenue, they would still most likely have additional wastes such as; food organics (from employees), shipping materials (straps or liners) or chemical containers (oil, lubricants for machines) all of which would need to be disposed. It can be hypothesized that these types of wastes which are not typically sold for revenue would be sent to landfill. In general, these examples suggest that companies are more interested in offering or requesting materials which will be most profitable and overall suggests that moving up the waste hierarchy is not desired because it would result in a loss of possible monetary profits.

A second trend which caused a lack of movement in the waste hierarchy and became apparent through conversations is that companies only tended to focus on their common wastes meaning that they often became involved or responded to the program because they found issues in getting rid of certain and specific materials. In most instances companies' common wastes were materials which were not easily recyclable such as mixed plastics or materials which were commonly used in their production (wood and cardboard). Larger quantities of particular materials posed issues for companies as they often had no place to store the wastes and therefore were paying large sums to have it hauled away frequently. Getting the company contact to think outside of what was already being recycled in their waste stream proved to be difficult which is evident by the trends in the data. For example, the "other" category ranked second in the total offers and requests and represented unique wastes only offered or requested once. These wastes were classified in an "Other" category as they were very distinctive and only appeared once. For example, one company requested *Tassimo Coffee Disks* and another requested cigarette waste and another offered insulation. These "unique" wastes represented only 11% of the entire wastes

offered or requested. In comparison, plastics composed 26% of total wastes offered and requested. This difference suggests that companies are less likely to offer not so common wastes such as the examples given. In some instances, identification of additional wastes came about through additional probing of the contact or through company site visits where the facilitator would see the entire production process. In some instances the facilitator was able to identify other wastes that the company contact may not have included in the initial data collection. For example, one general manufacturer produced materials using metal and offered solid iron cores to the exchange. However, through discussion it was identified that plastic bale ties could be added to the exchange as a waste as these were used to ship some of the product out. This waste was identified by discussing the overall process of the company. This example and the lack of "unique" wastes suggest a possible trend that there may have been additional companies where not all possible wastes were identified due to a lack of communication or recycling and waste knowledge. This example also suggests that this project was not able to capture the full range of possible wastes to be exchanged and only truly realizing some of the opportunities. Having companies see the benefits of moving up in the waste hierarchy was difficult unless there was a motivating factor. In the case of this study the motivating factors were wastes that were most common and proved to compose a large amount in the companies recycling stream. Again, movement up the waste hierarchy was not necessary for most companies and is an additional reason why not all waste exchange opportunities were explored.

An additional challenge of the exchange was the small number of companies who requested waste. One point already discussed was the problem that very few companies were responsible for the majority of the possible exchanges as identified by the database. It became obvious with this study that companies are far more likely to offer waste from their company

than to ask or request waste as there were 180 offers compared to only 70 requests. There are several hypothesized explanations for this trend. One, a company may not request a waste because they have no need for it. Two, a company may not realize they can request waste and may not recognize the link between wastes and production inputs. Three, the material may not be in the correct, proper or high enough quality to produce with resulting in a failure to exchange or even request. In most instances the only companies who requested wastes were already in the business of recycling materials or specified in making new product out of recycled products. For example, many companies that requested waste were electronic or metal or plastic recyclers and were in the business of receiving and requesting waste on a customary basis as well as manufacture that made products from recycled plastics. As the data collection progressed the facilitators began to prompt companies in reminding them that this project's focus is an exchange and for it to be successful companies need to take the waste. This issue again resulted in little movement away from the mindset and focus on the bottom of the waste hierarchy. For example; plastics, metals and electronics represented the top materials requested; however, there were some wastes requested which were categorized as "Other" wastes meaning that they were unique and were wastes that were only requested once. These materials included items like; sand, glue, furniture and roofing materials. These materials could suggest that the exchange is providing some opportunity for companies to seek out unique wastes. On the same note, these wastes could also represent a slight movement up the waste hierarchy for some companies as they are trying to find solutions for wastes which would otherwise be sent to landfill. However these wastes only represent 11% of all of the wastes suggesting most companies still are not focusing on uncommon wastes. It is important to note that some companies may not actually produce wastes

which would involve materials such as sand or glue which would prevent them from requesting or offering these types of materials.

Although most companies try to focus on the environment and sustainability; they are very profit driven and try to reduce costs in any way possible. This drive to reduce costs associated to waste is one motivating factor to get companies involved in a waste exchange in the first place. However, the fundamental mindset of companies appeared to be focused only on getting rid of wastes not taking in wastes as evident by the considerably higher amount of offers (72%) than requests (28%). In the larger picture, waste in a waste exchange becomes a resource, but in a culture where humans consider waste for what it is, companies simply do not think they need it. This failure to conceptualize waste as a resource is discussed further in Section 5.

In many ways, the waste exchange was successful garnering achievement by contacting companies and establishing potential exchanges. However, on the other hand the exchange was not as successful as it could have been as explained by the three scenarios above. Nonetheless, in the future as the study continues, or in future studies, these issues could easily be resolved by addressing the major faults and expectantly capturing the full potential of the waste exchange.

5.3 Research Questions Revisited

The outset of this study surrounded four major research questions. These questions support the major purpose of the research study of which was to establish a working by-product exchange to determine its influence on Municipal Solid Waste Planning (MSWM). The research questions below have been answered providing generalized conclusions to this research project.

5.3.1 Experiences of Waste Exchanges

Several of the Canadian Waste exchange programs and the Kalundborg example were summarized in the literature review section. These examples highlighted the general framework

for how exchanges function and succeed. In particular, the examples of the Calgary Materials Exchange, the BC Materials Exchange, Burnside/Dalhousie and the Quebec Industrial exchange all demonstrated that among numerous other factors, staff and funding became most critical for a successful exchange. These exchange programs examples were important for understanding how the Toronto Pearson Exchange would best be established and operated. It was obvious from the summaries that the need for active facilitators is critical for the success of the exchange programs and that a website alone is not sufficient to effectively run waste matches. The Emerald Group conducted a summary report of several waste exchanges in Canada and determined that most operators felt an exchange could be effectively maintained and operated by two people. It was also concluded that despite the size of exchange, the single most commonly raised issue amongst operators was the need for several years (i.e., 3 to 5 years) of stable funding for the proposed start up of an exchange. Funding became most important to secure and guarantee long-term employment to operate the active exchange. The same report also recommended that 2 full time employees would be sufficient to operate an exchange the size of the one in the Pearson Eco-Business Zone and that the staff could be increased as warranted. One of the major lessons learned from this project was that 2 staff was not sufficient to run an exchange this size and that several more would have likely contributed to a higher success rate, at least in terms of increased communication. For example, both the Calgary Materials Exchange (CMEX) and the Burnside Eco Industrial park demonstrated that more than 2 full-time employees were required. For example the CMEX has 9 full-time stuff operating the 503 company program, and the Burnside EIP has 10 full-time staff operating the 1400 company program. These examples suggest that the 337 companies within the Pearson exchange should have more than one full-time and one-part

time staff managing the exchanges. It is hypothesized that more staff would have increased the focus on communication between the companies and resulting in a more active exchange.

5.3.2 Connection between Waste and Resources

The literature reviewed how the connection between waste and resources first emerged during World War II when recycling of paper and metal began due to a lack of these resources. However, during the 1970s people became aware of environmental degradation due to increased human settlement which again resulted in changing views on sustainability and the environment and lead to an increased awareness of the connection between waste and resources (Vergara and Tchobanoglous, 2012). Viewing waste as a resource means that wastes are part of the resource cycle in which wastes are used as the inputs of production. Viewing waste as a resource therefore means that waste is not considered waste, but instead as a valuable resource. The literature also discussed how resource recovery is an important concept to economies such as India that largely depend on the secondary materials for income. This research revealed that there seems to be only a small connection between waste and resources and that the majority of users of this exchange failed to conceptualize the wastes as valuable resources. For example, A total of 24% of companies had some (16%) or all of their waste (8%) being sold for revenue and many companies refused to contribute waste to the exchange program if it was already being recycled in some way. Refusal happened even if it would result in better environmental practices and be utilized as a resource. In addition, companies did not want to contribute wastes to the program if it would result in them loosing money. There was also a clear lack of conceptualization between looking at waste as a resource or input as very few companies actually requested waste. Requests made up only 28% of total wastes compared to 72% that were offers suggesting that companies were far more willing to get rid of waste than take it. Finally, the majority of wastes offered and

requested were common wastes and easy to categorize suggesting a failure to look beyond the products that are easily recycled and well known.

These trends suggest several conclusions regarding the lack of a connection between wastes and resources. First, it is obvious that unlike countries that rely on recycled materials and waste exchanges as a form of income, companies did not choose to participate so they would make money, but rather so they could save money. For example, 72 percent of all materials were offered compared to only 28 percent that were requested suggesting that companies very focused on the bottom line: removing wastes for the lowest cost possible. It is obvious that the program was more attractive for people looking to get rid of their wastes rather than take in wastes. This example also suggests that there is only a few companies realize a connection between waste and resources and using wastes as a means of production. In addition, 8% of all companies were involved in revenue recycling only meaning that their production wastes result in pure profits for them. In these instances companies did not offer wastes to the program in fear that they would not be offered as much money or make money if they participated. This example suggests that the exchange was not economically attractive for some of the participating companies. This trend therefore suggests that companies were more concerned with costs than the environment, truly failing to see the true connection between wastes and the resource cycle. Secondly, it became obvious that companies did not look outside of their common everyday wastes and think about the greater possibilities of the waste exchange. Companies were focused on removing wastes and did not seem to understand the bigger picture of the waste exchange and the possibilities that their waste pool could have for other companies. For example, companies were very unlikely to offer or request a ‘unique’ waste (1.5% of all requests and offers) suggesting that these companies failed to see the full possibility of a waste exchange and how it may benefit their

production costs and footprints. The low frequency of these unique wastes is particularly suggestive of a trend where companies for the most part did not focus on the idea of an exchange. Only 25 of the 250 materials and offers were considered unique or specialized and materials in this category include items such as: cigarettes, coal, clothing and roofing materials. So few of the offers or requests fell into this category suggesting that companies are more focused on getting rid of wastes that are common to them or ones they will receive revenue for such as: plastics, metals and wood. Companies were unwilling or not aware enough to look beyond the recycling level of the hierarchy suggesting that companies did not see the true connection between waste and resources.

5.3.3 The Need for a Working Waste Exchange

The synopsis of the Ontario Materials Exchange program in the literature revealed that although it was once a real functioning successful exchange, for reasons unknown it is no longer functioning. In 2010 The Emerald Group reported: "there may be an opportunity to revive the existing Ontario Waste Exchange with new software and sufficient staff to build on any existing goodwill and brand name remaining with that organization" (p. 42) suggesting that there is potential for this exchange to once again be successful. The brief summary of the environmental movement suggests that as time progresses people are more willing to practice business in a sustainable manner and be more likely to support movement up the waste management hierarchy. This need to practice sustainable production and waste management was noted by several authors in the literature who explained that increased scrutiny of solid, liquid, emission and hazardous waste management and pollution prevention practices has resulted in increasing pressure on regional and local governments to manage waste and prevent pollution more effectively (Rathi, 2005; Boyle 2000; Hung et. al, 2006). This growing appreciation for the

environment in recent decades suggests that a re-launch of a program similar to the Ontario Materials Exchange may receive more support and active engagement than in previous decades. This previous lack of engagement and success of the Ontario Exchange also argues that there may be a need for education or awareness as it relates to the recognition of waste as a resource. One of the challenges of establishing the working exchange program in the Toronto Pearson EIP was the fact that it was difficult to get companies to provide wastes that they already were disposing. For example, 8% of the companies involved in revenue recycling did not offer wastes to the exchange due to a potential loss in income. In other words, it proved difficult to convince companies of the various benefits of participating in the exchange and the benefits of moving up in the waste management hierarchy. Rashid et al. (2008) discusses various sustainable manufacturing practices and suggests that manufacturers often struggle with the dilemma between the ease of implementation of a sustainable strategy and the breadth of impact it may have. This point argues that companies may not want to become involved with the exchange if it is complicated or difficult to be actively engaged. It is possible that companies viewed this program as a challenge because they knew little about how it would function or truly affect them. Companies also may not have understood the direct impacts of engaging in the exchange. However, with proper education, marketing and awareness, the benefits of the waste exchange could be promoted and possibly result in increased engagement. To further this point only 28% of the materials were requests compared to 72% of offers suggesting that removing wastes is an easier thing for companies to accomplish.

The need for a waste exchange can also be realized when looking at the benefits as they relate to environmental planning and municipal solid waste planning. For example, both through its production and management, waste can have negative affects on air quality, water quality and

public health and can affect climate change. If waste is improperly managed, pollutants can harm land masses and water bodies and can put people's health at risk. Incineration of waste can emit pollution to the air and a large contributor to greenhouse gases (GHGs) includes landfills which emit methane (Vergara and Tchobanoglous, 2012). The management of waste also requires capital and operating resources from municipalities (Shekdar, 2009). Regardless of whether the waste is being managed through processing technologies or a landfill, these tools both require space of which may not be readily available or affordable for municipalities. The development of a waste exchange allows for waste to be moved up the waste management hierarchy so that it does not have to be processed or disposed which could mitigate for the negative aspects of planning and managing for municipal solid waste. These points also importantly suggest the need for the development and application of waste exchange system in Ontario.

5.3.4 Waste Exchanges and Municipal Planning

Municipal Solid Waste Planning is influenced by several drivers. Some of these drivers include; laws and regulations, changing technologies, protection of resources, public health and economic drivers associated with waste recovery and resources. The main reason for developing the by-product waste exchange was to apply concepts of eco-industrial parks within the Toronto Pearson Eco-Business Zone to help companies reduce environmental impacts and to determine if these concepts could be applied to the broader planning community. These concepts included Industrial Ecology and Industrial Symbiosis, both of which focus on the ideas of the exchange of resources in a closed-loop system or environment. By developing and implementing a by-product waste exchange program within the Toronto Pearson Eco-Business Zone concepts of Industrial Ecology and Symbiosis were applied to try to drive resource recovery among the businesses in the area. Although only one successful exchange has been created thus far, several

exchanges (13) are being reviewed and several companies have been in discussion regarding the exchange of waste. These results suggest that the application of concepts underlying Eco Industrial Parks such as a by-product exchange program can assist to drive resource recovery and sustainable waste management practices. However, it was also realized that users of the exchange are highly uneducated or unaware of the links between waste and resources as discussed in the previous section. This conclusion suggests that although a waste exchange can help to drive resource recovery, increased education and awareness may help to drive resource recovery even further. Additionally, there are no current provincial or federal regulations which directly mandate the exchange of waste among businesses or firms in Canada. This lack of legislation related to waste exchanges suggests that municipalities are likely not planning or educating for these types of material exchanges. In addition, all of the current exchange programs in Canada were created through non-profit organizations are completely voluntary and have no mandatory legislation guiding them. This suggests that concepts surrounding resource recovery are not being planned for in Canadian communities. If these concepts were applied to municipal planning and solid waste planning they could inform and educate municipalities on reducing environmental impacts associated to waste management. In addition, planning for resource recovery could help to reduce a municipality's waste related costs. For example, less reliance on disposal technologies and landfill management is required as resource recovery moves away from the recycling and disposal aspects of waste management. A governmentally regulated regulation regarding by-product waste exchanges would require cities to consider the benefits of resource recovery in the planning of a municipal solid waste system. In addition, for the greater success of waste exchanges in Canada the Government should take action to regulate the planning and organization of waste exchanges in industrial and surrounding areas. The

Pearson Eco-Business by-product exchange suggests that cities should not be planned without consideration of solid waste and resource recovery therefore suggesting that concepts related to Eco-Industrial parks should applied to all municipal and city planning moving forward. Specifically, how these concepts could be utilized is discussed in detail in Section 5.4.

5.4 The Role for Planners

One of the major research questions of this study was to determine if concepts related to eco industrial parks and waste exchanges could help to guide and inform municipal planning. The ability for exchanges and eco industrial parks to promote sustainability and efficient waste management suggests that these concepts should in fact be applied to municipal planning. However, what is lacking from the results is clear direction on how these concepts might be applied or used to inform planning. Utilizing examples of cities throughout North America and Europe, the following section describes how planners at all levels of the government can utilize these concepts to inform solid waste planning. These examples suggest that planners must take an active role in educating themselves and their communities on these concepts and must actively engage and promote these concepts to see more effective and efficient municipal waste planning.

Federal Waste Planners

In Section 5.3 it was briefly discussed that regulations could play a key role in assisting with promoting ideas of resource recovery and conservation through mandatory waste exchange programs. Although mandatory regulations may help in engaging companies in the ideas of resource recovery and conservation, it is argued by many authors that indirect policies and regulations at the federal level can easily assist with participation and engagement in waste

exchanges. For example, in a study completed by the European Commission it was determined that the main driver for industrial ecology initiatives is financial gain and that regulations play a smaller, more indirect role (Lehtoranta, 2011). In a study on a Finnish pulp and paper mill for example, there were no policy instruments that promoted an industrial exchange but rather it was the best financially feasible solution. However, it was noted that there were several indirect regulations which had an effect including; a limit on phosphorus and nitrogen loads, air pollution control and waste reduction targets. Further, in 2012 Finland enacted the *Finish Waste Act* which was developed to improve material efficiency in all related activities such as appropriate utilization of wastes instead of waste to landfill and steering waste streams into preferred activities in line with the waste hierarchy (Pajunen, 2013). The implementation of the *Act* has had implications on the development of symbiosis and waste exchanges as there has been strong promotion for recycling and the increased use of recycled materials as well as the sustainable use of natural resources and the continuous improvement of waste management practices. Additionally, a case study on industrial symbiosis between a Finnish steel manufacturer, a pulp mill and paper mill concluded that pressure from market and financial benefits are the most important drivers for industrial actors (Pajunen, 2013). These two Finnish examples suggest that indirect regulations such as the *Finnish Waste Act* can help to influence and promote concepts of waste exchanges. In general, these examples suggest that regulations not directed at forceful engagement or involvement in waste exchanges helps to promote waste exchanges and that acts or regulations that influence cost have added affect. It is noted that at a federal planning level, planners could advocate for policy changes as related to waste management. Planners could target indirect policy including; landfill bans, tipping fees, increased energy prices, waste reduction targets or pollution control to try to promote and encourage waste exchanges and

increased recovery and conservation resulting in more efficient and effective solid waste planning.

Eco-industrial parks have recently become quite prevalent in China and in order to evaluate and manage the performance of these parks, the Chinese government through the *State Environmental Protection Administration* (SEPA) has set up the first national standard for EIPs (Geng, et al., 2008). With over 6, 600 industrial parks, the SEPA wanted to ensure that all park managers have the understanding of how to manage and continue to develop their parks sustainably. The general objective of the SEPAs program is to encourage, manage and monitor EIP projects by setting up criteria and indicators. The SEPAs standard has recognized that there many types of industrial parks in China and have developed general guidelines. For example to apply to become a national EIP demonstration project a park must meet the criteria as follows:

- All national environmental laws and environmental regulations must be enforced within the park; in the preceding 3 years, no pollution accidents or dramatic events related to ecosystem damage may have occurred.
- Local environmental quality must meet national environmental standards. No tenant companies may exceed pollution limits, and the overall emission should below the control target set by SEPA.
- The EIP plan prepared by the park manager must be evaluated and passed by SEPA and approved by the local government.

The indicator standards include criteria on economic development, material reduction and recycling, pollution control and administration and management. There is no financial support to apply or be in the national program and it is completely voluntary. However, there is a drive to be involved in the program as it provides parks with a "green" image attracting companies and industries (Geng et al., 2008). This example of a national standard is critical in showing a tool that federal planners could develop to encourage companies to be engaged in concepts of resource recovery and waste exchanges. Table 6 below highlights several benefits of applying a

standard as such to an industrial area and demonstrates key selling features planners could utilize to when developing a standard as such. Overall, SEPAs National Eco-Industrial Park Standard represents a significant step forward for planners in demonstrating a tool to assist in developing and managing eco industrial parks. Municipal planners could utilize lessons learned as well as the criteria and indicators to better manage and plan for municipal solid waste.

Table 6: Key Benefits of a National Eco Industrial Park Standard (Geng, et al. 2008)

Economic Benefits	Environmental Benefits	Societal Benefits
Lower insurance costs	Conservation of natural resources	Improved Pubic Health
Lower Waste treatment costs	Reduced environmental emissions	Improved public environmental awareness
Increased revenues from the sale of wastes	More efficient materials and energy use	New business and employment opportunities
Increased sales of green marketing	Less use of toxic materials	Improved community relations
Avoidance of (waste related) penalties	Improved environmental quality	

One study further noted that regulatory support plays an important role for the success of industrial symbiosis and exchanges. For example, research in Finland and Sweden found that although some regions have the technological and economic potential for industrial symbiosis, regulatory support is insufficient (Salmi, 2011). For industries or companies to engage in material or by-product exchanges they must ensure the waste definition of a material is changed with a non-waste by-product definition. Changing the waste status means that a company needs to apply for a new environmental permit. The permit process involves industrial actors to apply for permits through the environmental authority and the general public assesses and evaluates the application. If complaints are filed then the permit must be dealt with through a court process which means that the changing of a waste status tends to be time-consuming and expensive process. In addition, the system demonstrates a 'definitional struggle' between permit applicants, environmental administration, courts and the general public (Salmi, 2011). This example, although does not specifically identify a tool or resource for planners to utilize, it does suggest that companies may require aid at the federal regulatory level in making waste exchanges possible. It is evident that planners should ensure that companies do not get 'bogged' down in political bureaucracy that may well exist at the environmental permit and regulation process. To ensure planners can more effectively plan and manage waste, exchanges and their concepts of recovery and conservation need to be embraced. For companies to ultimately participate in these programs there needs to be a relatively easy engagement process. A role for federal planners exists here to ensure that environmental and regulatory compliance does not pose any threat to the development of waste exchange programs.

Provincial Planners

To ensure concepts related to waste exchanges including resources recovery and conservation are employed to waste planning; one must look beyond the federal role and focus also on the provincial planner's role. In Japan for example, planners utilize an industrial symbiosis modeling tool which incorporates Geographic Information Systems (GIS) and material flow data (Certow et al., 2004). The model allows planners to input how much material is going to certain locations which help planners determine what symbiotic connections and resources efficiencies can be made. The systems planning model is used to: identify points of consumption and emission; quantify the source points of various materials and identify areas suitable for policy. This model has been used to integrate industrial symbiosis concepts in the Muko River Basin as well in the city of Osaka to identify regions where there are construction and demolition materials demands (Chertow et al., 2004). This GIS model represents a tool and an example of planers using concepts of eco industrial parks and waste exchanges in real world situations to assist with resource and economic planning. This example from the literature also demonstrates how planners may use concepts to help inform and educate municipal waste planning in Canada. Looking to Northern Europe again, Finnish planners apply concepts of industrial ecology to the forestry sector. For example, 90% of paper in Finland is exported which some would argue is the opposite of maximizing the efficiency of resources in the industrial ecosystem (Chertow, et al., 2004). However, planners recognize that to successfully promote industrial ecology, the broader system boundaries, individual system components, and eco-efficiency vs. economic growth are all factors which must be evaluated and considered. Similarly, a case study of Cape Town, South Africa demonstrates the use of mapping material flows of copper among neighborhoods to show how wealth and class affect the flow of copper (Chertow, et al., 2004). Utilizing GIS mapping tools in these examples allowed researchers to break down data and provide policy

recommendations at the local level. This study concluded that planners and policy makers may not have been able to offer targeted policy options if data were only available at the collective level. Further, in Norway, research suggests that analysis of industrial networks and waste exchanges should be made from a higher level suggesting that planners and researchers need to move beyond the facility level and start thinking about waste exchanges and symbiotic networks from a regional or national level (Chertow, et al., 2004). This research argues that there could be a role for planners to look beyond local waste exchange opportunities, and to provincial and trans-boundary waste exchange possibilities. Lastly, research completed by the European Commission suggests that policy directed through land-use planning could help to encourage industrial ecology development (Lehtoranta, 2011). For example, provincial governments could encourage companies to locate close to one another with fiscal incentives or through mandatory permits or land-use regulation.

To summarize, these example demonstrate how planners might use concepts of waste exchanges and eco industrial parks to advance municipal waste planning at the provincial level. By showing the various tools and strategies many other global countries have used, it is obvious that there is a role at the provincial level for planners to more effectively plan for cities.

Municipal Planners

Looking first at planners at the federal level and then the provincial level, it is only natural to look at how municipal planners may use concepts of eco industrial parks and waste exchanges to more effectively manage and plan waste.

Eco Industrial parks have a long history of success in Denmark as one of the first ever EIPs called Kalundborg formed there (Jacobsen, 2006). Planners in Copenhagen Denmark express that there are three conditions usually present for eco-industrial developments to successfully

develop. First, there has to be industries that occupy specific niches. Secondly, there should be interest from a public agency, usually a local economic development office or a regional/ or local planning department to assist with facilitating partnerships. Third, the policy environment can foster eco-industrial development (such as landfill bans, high tipping fees, high energy prices) (Chertow, et al., 2004). This example clearly states that success of eco-industrial parks in Denmark is attributed to having connections and relationships with the regional and local planning departments or equivalent. This example further suggests that for eco industrial parks and waste exchanges to see success, planners at the local level must engage themselves in the development and organization of them from the outset.

Further, researchers at Yale argue that to promote industrial symbiosis and eco industrial parks, a facilitator or a champion should be targeted (Chertow, et al., 2004). The champion could for example be from the city planning department or from the local chamber of commerce. This champion would help to facilitate and coordinate partnerships and this role is critical in bring the members of the park and exchange together. It is also noted that the objectives of the park should be made clear at all times suggesting another important role for the planner. Further, it is argued that there is a role for legal experts and experts of planning laws as they can contribute their knowledge of the legal system and improve understanding around legal, environmental or regulatory barriers to eco industrial park formation. There is also a role for economic planners as their understanding of economic activities is important to material flows and business development. Generally speaking it is clear that there is a role for local and municipal level planners and that this role is to actively engage and support activities as they relate to the development of eco industrial parks and waste exchanges. Authors Cote and Wright (2006) discuss strategies for enhancing sustainability and resource conservation using a case study

example of industrial symbiosis. They explain that there are several barriers to developing waste exchanges and symbiosis and can be generally categorized as technical, economic, geographic, regulatory, legal, business, social, temporal and informational. The authors provide strategies to each of these barriers and suggest for example to tackle the 'informational' barrier that managers and technical personnel have to be comfortable enough to communicate regularly, educate and exchange information. They further argue that the United Kingdom is particularly successful at overcoming such barriers and occurs with the 'right attitude' on part of not only the industry but, planners, regulators and communities (Cote and Wright, 2006).

Conclusion on Role for Planners

Examples drawn from the literature demonstrate how planners globally utilize concepts of eco industrial parks and waste exchanges to currently plan cities and manage waste. It is obvious that there are tools and resources that planners can and should use to not only develop eco industrial parks, but also to manage and foster their continued development. It is also evident that to effectively and efficiently plan for municipal waste, planners cannot sit idle, but that there is an active role for planners at all levels of the government to engage and actively participate.

5.5 Results and application to Literature themes

Section 2 of this paper highlighted the current and existing literature which provided the context for the case study in the Pearson Eco Business Zone. There were several concepts and topics discussed, however, there are a few major themes that appeared in the literature which can be discoursed in context to the results of the case study and the development of the waste exchange.

Waste Management Systems

The first major section of the literature review discussed the various aspects of Waste Management, particularly the idea that waste management is considered as a system. The same concepts of systems were expressed when discussing Industrial Ecology and Industrial Symbiosis. It was expressed that a systems approach to managing waste and transporting waste is important due to the large quantities that exist in certain areas (Shekdar, 2009; Geng et al., 2007). Further, a systems approach is significant in establishing the sharing of resources and concepts of resource recovery (Hoffman, 2003). The results of the case study demonstrate that the system approach was a critical portion of the exchange as wastes were to be exchanged within a system of existing companies. It was noted in the results that several exchanges (73%) did not occur because there was a lack of response from one or both of the companies. Looking at the Pearson exchange as a system it was clear that without one part of the system functioning (the company) the process of the exchange was not entirely possible. The results suggest that all parts (all companies) of the waste system (the exchange) must be functioning and engaged or the waste system fails.

History of Solid Waste Management

The literature highlighted a succinct historical picture of the changing practice of waste management. The practice is one that has transformed from a focus of health and sanitation to the practice of resource protection. This idea of resource protection has also contributed to philosophies of sustainable waste management and resource recovery. Generally, waste management today is a focus on environmental protection due to rapid increases in population and industrialization (Rathi, 2005). As evidenced by the study it is apparent that practices of sustainable waste management are not necessarily driven purely through protection of the

environment. There are two major examples of this from the case study results. First, only 28% of the materials in the study were waste requests compared to 72% of waste offers. This suggest that companies were more concerned with simply removing wastes and not taking in wastes and argues that most companies do not either understand concepts of resource recovery or they do not care. Secondly, all of the companies (8%) who were participating in revenue recycling did not offer their wastes to the exchange. This trend suggests that companies, even if their wastes could provide an exchange opportunity, did not want to loose the revenue that waste was already generating. Moreover, although a company's involvement in the exchange could have resulted in increased sustainable waste management, the actions demonstrated suggest that the practice of resource recovery is not widely accepted despite a general global movement towards this practice as stated in the literature.

Waste Management Systems and Municipal Planning

The third section of the literature discussed waste management in the context of municipal planning and expressed that the 'systems' approach is often applied as the framework for designing and planning municipal solid waste systems (Sirvastava and Nema, 2011). Ljunggren (1998) argued that due to complexities of planning for solid waste, computer models are now utilized for strategic planning and that they can assist in evaluating several aspects of solid waste management including economic and environmental points of view such as: waste treatment technologies and waste policies, potential for materials recycling and energy production, reduced waste generation and treatments of specific materials. Further, Pires et al. (2010) argued that all technical and non-technical aspects of a solid waste management (SWM) system should be analyzed as a whole as they are inter-related with one another and that developments in one area frequently affect practices or activities in another area. The literature suggests that municipal solid waste planning is done with an approach that encompasses

numerous aspects. As the results of the study show, there were several waste matches made, but only one successful exchange outright. Reasons for the unsuccessful matches included things like; cost, ease, lack of interest or time, lost company contacts, loss of revenue. These results suggest that there are various aspects that affect a waste exchange system. It can be concluded therefore, that to have successful exchanges, one should understand all of the possible internal and external factors that could affect the completion of an exchange. It is clear that a lack of understanding or mitigation for some of these factors lead to some failure in successful waste exchanges.

Drivers of Municipal Solid Waste Management and Planning

The literature demonstrated that there were four distinct drivers that force the planning and management of Solid Waste. These drivers include; legal drivers (laws and regulations), technological drivers (available technologies), regional and international drivers (solid waste flow as recyclable resources and pollution); and socio-economic drivers (population trends and public awareness) (Contreras et al., 2010). This study showed that most companies managed waste based on socio-economic drivers as well as minor legal drivers. For example, the majority of companies (53%) participated in a full source separated waste management program. The management of this waste was likely attributed to the (legal) regulations that exist in Ontario. In Ontario for example, Industrial establishments are required to source separate their waste to ensure materials are diverted to be recycled or composted (Service Ontario, 2011). This regulation is a clear example of a legal driver that affected this study.

Companies were also driven to manage their waste for economic reasons. For instance, 24% of companies received revenue for their wastes or recycled materials suggesting a big reason for managing waste is associated to cost. Further, 23% of companies were classified in the Waste and Remediation category meaning that their business is essentially taking in waste

and either using it to produce other products and materials or reducing and breaking up products to be further recycled. The fact that 23% of companies had a business in recycling and waste recovery suggests again that the management of waste is economically driven.

The main vision of Partners in Project Green and the Pearson Eco Industrial area is to promote green technology adoption as a way to reduce threats to the regions resources while building a sustainable economy. Essentially, the area is marketing as a place for companies to conduct sustainable and environmentally friendly business. This suggests that companies may have engaged in the waste exchange program for not only economical reasons, but also social reasons. Companies may have joined the waste exchange as a way to promote and market their business as being more sustainable particularly in regards to their waste management therefore attracting customers looking for a socially and environmentally responsible business.

Sustainability and Waste Management

In the literature it was argued that the traditional view of waste is that of a linear process. Simply, waste is a resource that is consumed. However, modern generations such as those that emerged in the 1970s, have a more sustainable view of waste encapsulating it as part of a resource cycle (Powrie and Dacombe, 2006). Further, Rathi (2005) argues rapid growth of population and industrialization is degrading the urban environment, placing stress natural resources and undermining equitable and sustainable development. These global changes are forcing cities to focus on promoting sustainable waste management practices. The case study demonstrated that companies are behaving in a sustainable manner, although not all waste matches became a successful exchange. For example, only 2% of companies admitted to not having a source separation waste program compared to 61% of companies that are actively diverting and recycling their waste. These results suggest that companies for the most part are engaging in recycling and sustainable waste management practices.

Waste Diversion and Procurement

As the literature expressed, diversion in its basic definition is, "the act or instance of diverting from a course, activity or use" (Websters, 2011). According to Waste Diversion Ontario (2011) waste diversion is when waste is diverted away from the landfill to either some sort of recycling or composting program. The results of the case study show that in fact companies for the majority are diverting their waste. For example, of companies that specified that they had a waste management program, at least 61% are participating in some form of diversion either through recycling, composting or revenue recycling. Only 2% of companies admitted to not diverting at all. There was a total of 34% of companies that did not specify what they do with their waste. Based on the high results (61%) of those that do divert, it can be hypothesized that large portions of that 34% do divert their waste. However, in Ontario it is mandatory for industrial establishments to source separate so it may be possible that companies did not specify as they did not have a source separation system in place and were fearful of possible fines or penalties (Ontario Guide, 2008).

Although most companies practice diversion, it is not so clear that companies engage in procurement. According to the literature, green procurement stems from pollution prevention principles and activities (Ho et al., 2010). Also known as green or environmental purchasing, green procurement compares price, technology, quality and the environmental impact of the product, service or contract (p. 24). In the study, it was obvious that companies are willing to provide wastes to the exchange, but are less likely to take in or receive wastes. For example, 72% of all materials were offered to the exchange, compared to only 28% of requests suggesting that companies are not so willing or interested in bringing in waste to be used as a resource. Looking at these results in the context of procurement, one could argue that based on the low number of

waste requests companies are not looking or interested in aspects of procurement or the purchasing of green or recycled products.

Industrial Waste

According to the literature, industrial waste refers to all wastes produced by industrial operations or derived from manufacturing processes and can encompass food wastes, rubbish, ashes, construction and demolition wastes, special wastes and hazardous wastes (Caseras, et al. 2005; Chertow, 2005). It was also identified that industries have traditionally managed their waste products by discharging them into the environment without previous treatment – a practice that resulted in an increase of pollution and produced a negative environmental impact (Caseras et al. 2005). As evidenced by the case study description and the study area, all of the companies were located in an 'industrial' park area, however not all companies in the study area were of a strict industrial nature. Part of the methodology of the study was to screen out certain sectors so only heavy manufacturers/producers were included. The screens removed companies that would not be producing industrial type waste such as; commercial and wholesales or hotel and restaurants ensuring that all waste was coming from an industrial operation. The existing literature and examples of waste exchanges focused on industrial waste so it was hypothesized that the best results may stem from using industrial type waste. Opposite of what the literature stated, the majority of companies treated their waste in some way preventing negative environmental impacts.

Eco-Industrial Parks

One of the most important roles of the literature was to offer an understanding of what an Eco-Industrial Parks is. This definition and related concepts were critical to the study as the exchange was to be developed in an existing Eco-Industrial Park. As learned from the literature,

definitions of Ecology, Industrial Ecology (IE) and Industrial Symbiosis (IS) provide a backdrop for the model of an Eco Industrial Park (EIP) and the relationship to environmental ecology. Through building relations between independent companies in the same geographical area, to improve the environment, industrial parks are becoming more common in an attempt to diminish the environmental pressure generated by industrial activities (van Leeuwen et al., 2003). Van Leeuwen et al. defines an EIP as "a clearly deliniated territory where, by means of cooperation, firms adjust their activities with respect to one another in order to diminish the total environmental impact without affecting the economic vitality of the individual companies" (2003, p. 148). As learned from the research on the Pearson Eco-Industrial Area it represents a well developed Eco Industrial Park. For example, the park is delineated by specific borders, encompassing a specific geographic area. The park is managed by one organization (PPG) whose goal is to incorporate ideas of ecology and sustainability with business. Lastly, a total of 51 companies cooperated to diminish waste by engaging and participating in an exchange program. Although, only one exchange was completely successful, the attempt to reduce environmental impacts by sharing waste defines the Pearson business area as an eco industrial park.

Experiences of Canadian Waste Exchanges

A major theme of the literature discussed the evolution of material exchange programs and eco industrial parks. The literature highlighted several existing exchanges as well as one previously existing exchange. These examples demonstrated the framework for developing waste exchange programs and assisted in understanding the management and operation aspect of exchanges. In addition, concepts of eco industrial parks and how these function as separate entities was discussed. As demonstrated in the five exchange program examples in the literature, it was clear that there are several key aspects which contribute to successful material exchange programs. The first clear indicator of success for these material exchange programs was the

presence of several dedicated full-time staff to run and coordinate the programs. For example, both the Calgary Materials Exchange (CMEX) and the Burnside Eco Industrial park demonstrated that several full-time employees were required. For example the CMEX has 9 full-time stuff operating the 503 company program, and the Burnside EIP has 10 full-time staff operating the 1400 company program. Further, the BRIQ exchange had 1 full-time facilitator to manage only 12 companies. All of these exchanges have been running for several years and have demonstrated numerous successful exchanges. Unlike the programs discussed in the literature, the Pearson case study was only allocated 2 full-time staff for a total of 337 companies which likely resulted in issues with company participation. For example, 117 companies initially responded with interest in the program, however, only 51 responded with real data. Further, 91 out of 124 possible matches were not explored or brought to fruition due to lack of response from one or both companies. This poor response rate and lack of involvement suggests that additional staff may have had more success in generating additional data and a continued partnership from companies.

The second indicator of success for the exchange discussed was the availability of funding for the exchanges. For instance, funding for the CMEX is provided through the City of Calgary, corporate sponsors, memberships and fees for waste audit services. Funding for the BC MEX is provided through the BC Ministry of Environment as well as corporate sponsors and municipal funding. Further, both the Dalhousie/Burnside and the BRIQ exchange received funding through private and government funding. For these exchanges funding was provided mostly to pay full-time and part-time employees. However, unlike these exchanges which had funding provided, the Pearson study did not have any additional allocated funding or resources and therefore could not hire or provide additional staffing. As articulated in the literature, it is

apparent that the ability to have several full-time staff and available funding either for project related costs or t hire additional staff is important in successfully running exchange programs. It is hypothesized that a lack of funding for the case study negatively affected response rates and communication with the companies involved.

Environmental Regulations

The last major theme of the literature was a synopsis of the existing environmental and waste related regulations that currently exist in Ontario. The literature discussed the establishment of the Canadian Environmental Protection Act and the 3 R regulations as well as the Waste Diversion Act which were introduced to specifically manage and control waste produced and generated in Ontario. These regulations and rules assist in reducing the amount of waste going to landfill and also assist in protecting the environment through control of waste. The literature also clearly demonstrated that there is a lack of discussion or discourse on waste exchanges in Canadian environmental law and revealed that there are no existing regulations guiding waste exchanges in Canada. As demonstrated by the case study, there were no specific rules or regulations directed at involvement in the waste exchange program. The lack of engagement in the program may have been a result of the lack of rules and enforcement. For example, 117 companies responded initially to outreach, however only 51 of those companies actually responded with data for the exchange. In addition, 8% of companies refused to offer their wastes at all, and only 28% of the materials were requests compared to 72% of offers suggesting that companies were less likely to engage in the full exchange program. The fact that there were so few companies willing to take in wastes made it very difficult to complete full material matches or exchanges amongst the companies. In general, the study results show that there was a lack of involvement, either outright with initially failing to provide data, or later on with lack of waste requests and offers. As established by the literature, the Ontario province

enacted regulations to specifically manage waste and force waste producers to divert and protect the natural environment and it was evident that the majority (61%) of all companies followed these regulations. If similar regulations existed which forced companies to become involved in developing or engaging in waste exchange programs, it is likely that there would be increases in overall participation. By having regulations and rules mandated by the government awareness and education about these programs and their benefits can also be raised. It is further hypothesized that if regulations existed which focused on exchanges of waste, participation in this particular study would have increased.

Conclusion on Application to Literature

The literature review highlighted several themes which set the context for studying and developing a waste exchange program in the Pearson Eco Business Zone. As discoursed above, there were several conclusions drawn around each theme based on the results regarding the development of an exchange program. These conclusions can now contribute to the existing literature regarding waste management and the development of future waste exchange programs.

5.6 Lessons Learned: Directions for Future Research

Although much of the discussion section of this paper highlighted the challenges of this project there are some lessons to be learned so that future studies focused on similar subject matter may be able to adapt and overcome the challenges. The challenges can be summarized as three major findings and are discussed below.

The first major lesson learned is that that it seems better to start with a smaller company outreach. Based on the experience CTTÉI had with their project BRIQ they started with 12 companies and were able to get almost 40 working exchanges. This smaller group of companies

meant that one facilitators' communication and outreach was focused on only a few people making for a stronger working relationship with the company contacts. Based on this, it seems that the working database for this project may have been too large and suggests that to have a more focused outreach the contact list of 337 should have been reduced – at least for the first few months. Generally speaking, it is recommended that starting smaller in any future studies will likely lead to increased success to a working by-product exchange.

The second major lesson learned is that it is important to ensure that all website and communication components are in working order. In the case of this project a major component of the outreach was affected by a French to English translation delay. This meant that no emails could be sent to companies automatically informing them of a potential exchange. Although this did not cause huge issues for the project itself, it did mean that the facilitator needed to spend more time sending emails and manually responding to companies. It is assumed that if the facilitator were able to spend less time doing these manual tasks there may have been more time to spend on other communication needs. Furthermore, the issue as related to translation also affected the company access to the database as they were not able to access and browse as they were intended to. It is possible to say that companies may have been more inclined to participate with access to the database as they would have been able to do this on their own time and not when prompted by the facilitator through email or a phone call. In addition, it is possible that more exchanges would have been successful as companies would have had access to all of the waste offers and demands and may have found an exchange opportunity that the auto match feature or facilitator did not. This may have also solved some of the auto-match issues where the offer or request description was wrong or poor resulting in the failure of the exchange identified.

Overall, the issues as related to the translation of the website did not contribute to major slowdowns to the project, but that it would have contributed to increased active engagement. A third lesson learned as it relates to communication and outreach is ensuring that companies understand that material requests are just as significant as material offerings. In this study few companies seemed willing to take wastes and were evident by the small amount of material requests (28%) compared to material offers (72%). This occurrence may have transpired as a result of the facilitator focusing more on waste offers outright in initial contact with companies. For example, companies were more likely to get involved if they knew they could save costs by removing waste for free. This meant that the facilitator often contacted them by explaining the benefits of the program of which are potential cost savings as related to waste removal. However, this tactic also meant less emphasis on taking wastes. This lack of focus on requests proved to be an issue when it came time to making matches as there were only some companies actually willing to take wastes. More emphasis outright upon initial contact with the companies about the importance of material requests should be provided and would allow for a deep understanding of the links between wastes and resources.

The principal lesson learned in this project relates to communication and outreach. As demonstrated in the discussion portion of this paper, the largest contributor to the unsuccessfulness of completing the potential exchanges was lack of response from companies who initially expressed interest in the project. This lack of response meant that the majority of potential exchanges identified did not get explored to determine if they could be successful. It is recommended that for future studies or for the continued outreach of the project, that the PPG and its facilitators identify company champions that will see the project and matches to fruition or at least until all potential matches have been explored and exhausted. For example, the

database highlighted one company who would be responsible for over half of the total potential exchanges. This particular company did not respond to any communication informing them of the potential matches which contributed to the low success rate. Company champions within this project would help to establish a sense of commitment and other companies may be more inclined to participate if they are seeing their fellow sector associates champion and support the project. Although getting full commitment from companies may be difficult, it is suggested that some accountability be applied to the company. For example a contract in which the facilitator and company contact signs a communication schedule might be possible solution. This is something that may have help to ensure more constant communication and follow-up on potential successful exchanges identified.

In general, it is assumed that this project would have seen far more success if the company response rate was higher and therefore suggests that accountability in some form may be beneficial to future studies of a similar nature.

5.7 Project Continuation

5.7.1 Channel Partner Launch

The Communication Plan also identified in detail the continuation of the project beyond the focus on the waste exchange. Phase 2 identified as the Channel Partner Launch although set to begin originally in October, began in mid-December of 2012. Phase 2 has an emphasis on engaging haulers, brokers and consultants. The purpose of this phase is to introduce these stakeholders to the program and demonstrate how these companies can influence or assist in creating an effective waste exchange. In addition, it is anticipated that these stakeholders will be able to provide waste solutions to companies who may not have an ideal waste for the exchange program.

5.7.2 Ongoing Recruitment and Program Maintenance

Ongoing Recruitment & Program Maintenance (Phase 3) will continue to recruit companies to participate in the program and refine the data collection process as needed. The outreach and building of the by-product exchange (Phase 1) will continue through the full-time facilitator with PPG. The exchange will also continue to grow as more companies are added to the database. In addition once the initial contact list is exhausted more companies from the PPG company database will be added.

The ongoing communications for the program includes:

- Permanent program page on the Partners in Project Green website.
- Periodic news stories highlighting companies that have found by-product synergies through the program.
- Yearly by-product exchange and/or waste events where the program is promoted to area businesses.
- Ongoing promotion of the program at other Partners in Project Green events via presentations and print materials.
- Promotional brochure and/or poster that is made available online and at events.
- Recognition of program participation in the Partners in Project Green Programs Database.
- Continued promotion of the program via Partners in Project Green Eco-Efficiency team members when they visit companies to perform their energy assessments.
- Report on by-product synergy results as part of the Pearson Eco-Business Zone Annual Report.

The final two phases of the project, although outside of the scope of this paper, are extremely important in continuing the already working by-product exchange established by the launch of this project. Part of the unsuccessfulness of the project was due to a lack of responses from companies, but also a lack of companies requesting waste. By continuing to update the database and expanding beyond simply waste producers it is anticipated that the waste exchange will function more successfully once broadened to include haulers, brokers and other stakeholders. In addition, constant upkeep and program maintenance will ensure successful exchanges continue beyond the initial exchanges.

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Appendix A: Data Collection Sheet

BY-PRODUCT SYNERGY DATA COLLECTION			
DATE:			
INTERVIEWER:			
*NOTE: Fields in **BOLD** are mandatory			
GENERAL COMPANY INFORMATION			
COMPANY NAME:			
INDUSTRIAL SECTOR (NAICS):	11-Crop production and horticulture	☐	NOTES:
	23-Construction	☐	
	562 - Waste Management	☐	
	81- Other Services	☐	
	311-Food	☐	
	312 - Beverage and Tobacco	☐	
	313-Textiles and clothing	☐	
	316-Technical textiles	☐	
	321-Wood	☐	
	322-Paper	☐	
	323 - Printing and related	☐	
	325-Chemicals	☐	
	326-Plastics and rubbers	☐	
	327-Non-metallic minerals	☐	
	332-Metal products	☐	
	333 - Machinery	☐	
	334 - Computer and Electronic	☐	
	335 - Electrical Equipment	☐	
	337 - Furniture	☐	
	339 - Miscellaneous Mfg.	☐	
WEBSITE:			
NUMBER OF EMPLOYEES:			

	ADDRESS:	
	CITY:	
	PROVINCE:	
	POSTAL CODE:	
	PHONE NUMBER:	
	FAX NUMBER:	

DESIRED USERNAME FOR TOOL:	
DESIRED PASSWORD FOR TOOL:	

MAIN CONTACT PERSON:		
	TITLE:	
	FIRST NAME:	
	LAST NAME:	
	EMAIL:	
	ADDRESS:	
	CITY:	
	PROVINCE:	
	POSTAL CODE:	
	PHONE NUMBER:	
	FAX NUMBER:	
ADDITIONAL CONTACT PERSON (IF APPLICABLE):		
	TITLE:	
	FIRST NAME:	
	LAST NAME:	
	EMAIL:	
	ADDRESS:	
	CITY:	
	PROVINCE:	
	POSTAL CODE:	
	PHONE NUMBER:	
	FAX NUMBER:	

Inputs (Requests for Materials)

Material name	Material category	Material subcategory	Other (specify)	Intended use	Classification	Quantity needed	Units	Frequency	Other desired characteristics (particle size etc.)	Allowable contaminants	Contaminant percentages	Physical state	Additional notes (terms & conditions)
EXAMPLE	*Wood*	*Raw wood*		*Furniture manufacturing*	*Non-hazardous material*	*500*	*Pounds*	*Monthly*		*Raw wood. No contaminants allowed.*	*0%*	*Solid*	

Outputs (Offers for Materials)

Material name	Material category	Material subcategory	Other (specify)	Origin (process)	Classification	quantity available	Units	Frequency	Other characteristics (particle size etc.)	Contaminants	Contaminant percentages	Physical state	Relevant data (ph, colour, flashpoint, granulometry etc.)	Current packaging	Price offered	Current disposal method	Approx. Disposal costs (per ton or year)	Waste hauler/broker employed	Additional notes (terms & conditions)
EXAMPLE	*Wood*	*Dust and sawdust*		*Result of sanding/sawing process*	*Non-hazardous material*	*1*	*Large dumpster (360 L)*	*Monthly*	*Fine dust*	*None*	*0%*	*Dust*		*Container*	*FREE*	*Picked up by waste hauler*	*$200/year*	*ABC Waste*	

Possible Materials and Categories

Material categories	Material subcategories	Classification
Acids	Amino acid	Non-hazardous material
	Phosphorous acid	Hazardous material
	Sulphuric acid	Does not apply
	Hydrochloric acid	Unknown
	Other inorganic acid	
	Other organic acid	
		Frequency
Bases	Caustic soda solution	
	Lime	Annually
	Carbonate	Monthly
	Other (specify)	Weekly
		Daily
Other inorganic compounds	Gypsum	One-off
	Refractory bricks	
	Inorganic pigments	**Units**
	Catalyst and residues	
	Silica	Litres
	Inorganic carbon	Gallons US
	Ashes	Cubic meters
	Gas	Cubic yards
	Mineral salt	Small dumpster (240 L)
	Other (specify)	Large dumpster (360 L)
		Kilograms
Solvents and residues	Alcohol	Pounds
	Chlorinated solvent	Tons
	Acetone	Metric tons
	Halogenated solvent	Kilowatt hours
	Non-chlorinated solvent	Megawatt hours
	Sludge	Giga joules
	Other (specify)	Pieces/Units
Other organic compounds	Glue	**Physical States**
	Polymer	
	Flocculant	Aggregate
	Glycerine	Sludge
	Organic pigments	Cake
	Hydrocarbons	Gas
	Other (specify)	Liquid
Oil	Cutting oil	Dust
	Vegetable oil	Solid
	Mineral oil	Suspension
	Oil filter	
	Grease	**Packaging**
	Other (specify)	
		Bin (tote)

Platics and rubbers	HDPE (#2) High density polyethylene	Bundles	
	PET (#1) Polyethylene terephthalate	Container	
	PS (#6) Polystyrene	Barrel	
	Scrap tires	Palettes	
	Rubber	Loose	
	PP (#5) Polypropylene	None	
	Plastic containers		
	Mixed plastics		
	LDPE (#4) Bags and films		
	Resin		
	Other (specify)		
Fabric, textiles and fibres	Soiled leather		
	Natural plant fibres		
	Clean textiles		
	Soiled textiles		
	Natural animal fibres		
	Natural mineral fibres		
	Synthetic fibres		
	Clean leather		
Wood	Contaminated wood		
	Raw wood		
	Scraps		
	Wood chips		
	Dust and sawdust		
	Pallets or skids		
	Plywood		
	Treated wood		
	Other (specify)		
Metal and metal sludge	Alumina		
	Metallurgical residues		
	Non-ferrous metals		
	Ferrous metals		
	Aluminium		
	Ore		
	Slag		
	Soft steel		
	Galvanized steel		
Paper and cardboard	Office paper		
	Newpaper		
	Mixed paper		
	Paper + plastic		
	Paper + metal		
	Contaminated paper		
	Cardboard		
	Contaminated cardboard		

	Waxed cardboard		
Glass	Glass containers		
	Pyrex		
	Glass dust		
	Crushed glass		
	Fibreglass		
	Other		
Soil	Heavy metal contaminated soil		
	Hydrocarbon contaminated soil		
	Clay		
	Vegetation		
	Sand		
	Gravel		
	Other (specify)		
Construction material	Gypsum		
	Stucco		
	Asphalt		
	Concrete		
	Cement		
	Insulation materials		
	Asphalt shingles		
	Crushed stone		
	Bricks		
	Other (specify)		
Coal and compounds	Coke		
	Carbon black		
	Anthracite		
	Graphite		
	Coal		
	Other (specify)		
Food and yard waste	Edible food waste		
	Inedible food waste		
	Agricultural residues		
	Other (specify)		
Paint and residues	Epoxy		
	Paint containers		
	Paint sludge		
	Alkyl		
	Latex		
	Polyurethane		
	Other (specify)		
Water	Contaminated water		

	Treated water		
	Water treatment sludge		
	Drinking water (ambient)		
	Stormwater		
	Steam		
	Water 0-10°C		
	Water 20-60°C		
	Water 6o-100°C		
Energy	Electricity		
	Natural gas		
	Wood		
	Coal		
	Gasoline		
	Propane gas		
	Fuel oil		
	Diesel		
	Other (specify)		
Other	Equipment/machinery		
	Office items		
	Electronic components		
	Fluff		
	Batteries		
	Neons		
	Other (specify)		
Acids			
Bases			
Other inorganic compounds			
Solvents and residues			
Other organic compounds			
Oil			
Platics and rubbers			
Fabric, textiles and fibres			
Wood			
Metal and metal sludge			
Paper and cardboard			
Glass			
Soil			
Construction material			
Coal and compounds			
Food and yard waste			
Paint and residues			
Water			
Energy			
Other			

Appendix B: List of Companies Contacted

Company	Company Contacted (Name coded by Type of Production)
1	Miscellaneous Manufacturing
2	Metal Manufacturing
3	Food Manufacturing
4	Waste Management and Remediation Services
5	Food Manufacturing
6	Paper Manufacturing
7	Waste and Remediation
8	Machinery Manufacturing
9	Food Manufacturing
10	Waste and Remediation
11	Waste and Remediation
12	Wood Manufacturing
13	Plastics Manufacturing
14	Metal Manufacturing
15	Printing Activities
16	Paper Manufacturing
17	Food Manufacturing
18	Waste and Remediation
19	Miscellaneous Manufacturing
20	Furniture Manufacturing
21	Furniture Manufacturing
22	Construction
23	Metal Manufacturing
24	Waste and Remediation
25	Metal Manufacturing
26	Furniture Manufacturing
27	Plastics Manufacturing
28	Plastics Manufacturing
29	Chemical Manufacturing
30	Waste and Remediation
31	Electrical Equipment Manufacturing
32	Waste and Remediation
33	Food Manufacturing
34	Waste and Remediation
35	Waste and Remediation
36	Waste and Remediation
37	Food Manufacturing
38	Miscellaneous Manufacturing
39	Food Manufacturing
40	Miscellaneous Manufacturing

41	Food Manufacturing
42	Plastics Manufacturing
43	Miscellaneous Manufacturing
44	Construction
45	Beverage Manufacturing
46	General Manufacturing
47	Waste and Remediation
48	Chemical Manufacturing
49	Miscellaneous Manufacturing
50	General Manufacturing
51	Food Manufacturing

Appendix C: List of Applicable Regulations

O. Reg. 101/94, 1990 - Recycling and Compost of Municipal Waste

The present Regulation lays down provisions relating to recycling and composting of municipal waste. A local municipality that has a population of at least 5,000 shall establish, operate and maintain a blue box waste management system if the municipality is served by a waste management system owned by or operated by or for the municipality that collects municipal waste or accepts such waste from the public at a waste disposal site. Furthermore, a local municipality that has a population of at least 5,000 shall establish, operate and maintain a leaf and yard waste system.

O. Reg. 102/94, 1990 – Waste Audit and Waste Reduction Work Plans

Ontario Regulation 102/94 Waste Audits and Waste Reduction Work Plan regulation applies to industrial, commercial and institutional (IC&I) entities including; retail shopping establishments, retail shopping complexes, office buildings, restaurants, hotels and motels, hospitals, educational institutions and large manufacturing facilities. O. Reg. 102/94 is a vital part of Ontario's efforts to encourage businesses to reduce the amount of waste they produce, to reuse whatever waste they can and to recycle the rest and is also a part of Ontario's 3Rs Regulations (3Rs stand for reduce, reuse and recycle) (Ontario Guide, 2008). The implementation of the IC&I waste audits and waste reduction work plans by those entities subject to O. Reg. 102/94 contributes significantly toward the success of the province's efforts to promote the diversion of waste away from landfills and incinerators as the preferred approach to waste management. IC&I wastes make up the largest component of the non-hazardous solid waste stream. For example, Statistics Canada reports that in 2008 (the most recent year for which data are available), 3.2 million tonnes of residential waste and 6.4 million tonnes of non-residential waste were disposed from Ontario sources. Efforts to divert the IC&I waste stream, therefore, will have the greatest

potential for reducing the quantity of materials destined for disposal and increasing the quantity put back into productive use.

Organizations and Establishments that must comply include:

- Retail shopping complexes of 10,000 +m2 floor area
- Class A,B or F hospitals under Ontario Reg. 964
- Schools with 350+ students at a location or campus
- Restaurants with gross annual sales of $3,000,000+
- Office buildings with 10,000 +m2 floor area
- Hotels and motels with 75+ units
- Building construction projects of 2,000 +m2 floor area
- Building demolition projects of 2,000 +m2 floor area
- Manufacturing sites with 16,000 employee hours per month

O. Reg. 103/94, 1990 – Industrial, Commercial and Institutional Source Separation Programs

Ontario Regulation 103/94 more commonly known as the; industrial, commercial and institutional source separation programs states that a "source separation program" must be put in place to facilitate the source separation of waste for reuse or recycling (Service Ontario, 2011). A source separation program required under this Regulation must include the following:

- the provision of facilities for the collection, handling and storage of source separated wastes described in subsection (2) adequate for the quantities of anticipated wastes;
- measures to ensure that the source separated wastes that are collected are removed;
- the provision of information to users and potential users of the program:
    - describing the performance of the program
    - encouraging effective source separation of waste and full use of the program
- reasonable efforts to ensure that full use is made of the program and that the separated waste is reused or recycled

As part of the source separation program, collection, handling and storage facilities must be provided for recyclable materials. The generator must make reasonable efforts to ensure that the system is used and that source separated materials are reused or recycled. The source separation program must have a communications component to promote the program, to instruct employees on how to use the program, and to provide feedback on how many materials are diverted.

Organizations and Establishments that must comply include:

- IC&I establishments in municipalities with 5,000 + population
- Retail shopping complexes with 10,000 +m2 floor area
- Class A, B or F hospitals under Ontario Reg. 964
- Schools with 350+ students at a location or campus
- Restaurants with annual gross sales of $3,000,000+
- Office buildings with 10,000 +m2 floor area
- Hotels and motels with 75+ units
- Multi-unit residential buildings with 6 or more units

- The following IC&I sectors must comply regardless of location:
    - Building construction projects of 2,000 +m2 floor area
    - Building demolition projects of 2,000 +m2 floor area
    - Manufacturing sites with 16,000 + employee hours per month

Regulations under the Waste Diversion Act, 2002

- **O.Reg. 273/02 Blue Box Waste**
    - Waste that consists of the following are considered Blue Box Waste
        - Glass
        - Metal
        - Paper
        - Plastic
        - Textiles
- **O.Reg. 542/06 Municipal Hazardous or Special Waste**
    - Waste that are considered "municipal hazardous or special waste" that consists of any of the following materials, or any combination of them, whether or not the waste is owned, controlled or managed by a municipality:
        - corrosive products, flammable products or toxic products, as those terms are defined in the Consumer Chemicals and Containers Regulations, 2001 made under the *Hazardous Products Act* (Canada)
        - Containers that display information that is required by the Consumer Chemicals and Containers Regulations, 2001 made under the *Hazardous Products Act* (Canada) for containers that contain corrosive products, flammable products or toxic products, as those terms are defined in those regulations,
        - flammable hazards, corrosive hazards or toxicity hazards
        - corrosive waste
    - ignitable waste
        - leachate toxic waste
        - reactive waste
    - "municipal special waste" means waste that consists of any of the following materials, or any combination of them, whether or not the waste is owned, controlled or managed by a municipality:

        - batteries,
        - pressurized containers,
        - aerosol containers,
        - portable fire extinguishers,
        - fertilizers, fungicides, herbicides, insecticides or pesticides, and containers in which they are contained,
        - paints and coatings, and containers in which they are contained,
        - containers that have a capacity of 30 litres or less and that were manufactured and used for the purpose of containing lubricating oil,
        - oil filters, after they have been used for their intended purpose,
        - fluorescent light bulbs or tubes,
        - pharmaceuticals,
        - sharps, including syringes,
        - switches that contain mercury,
        - thermostats, thermometers, barometers or other measuring devices, if the thermostats, thermometers, barometers, or other measuring devices contain mercury,
        - antifreeze, and containers in which it is contained,
        - solvents, and containers in which they are contained;

- **O.Reg. 33/08 Stewardship Ontario**
    - "steward" means a person designated as a steward under the rules made by Stewardship Ontario under section 30 of the Act in respect of blue box waste or municipal hazardous or special waste.
- **O.Reg. 85/03 Used Oil Material**
    - used oil material" means waste that consists of any of the following materials, or any combination of them:
        - lubricating oil after it has been used for its intended purpose,
        - lubricating oil that is not suitable for its intended purpose,
        - an empty container, having a capacity of 30 litres or less, manufactured and used for the purpose of containing lubricating oil,
        - an oil filter after it has been used for its intended purpose. O. Reg. 85/03, s. 1.
- **O.Reg. 84/03 Used Tires**
    - "tire" includes a part of a tire;
    - "used tires" means waste that consists of any of the following materials, or any combination of them:
        - used tires that have not been refurbished for road use,
        - tires that, for any reason, are not suitable for their intended purpose.
- **O.Reg. 393/04 Waste Electrical and Electronic Equipment**
    - "waste electrical and electronic equipment" means a device that is waste, that required an electric current to operate and that is,
        - a household appliance, whether used inside or outside a home, including any device listed in Schedule 1,
        - information technology equipment, including any device listed in Schedule 2,

- telecommunications equipment, including any device listed in Schedule 3,
- audio-visual equipment, including any device listed in Schedule 4,
- a toy, leisure equipment or sports equipment, including any device listed in Schedule 5,
- an electrical or electronic tool, including any device listed in Schedule 6, but not including a large-scale stationary industrial tool, or
- a navigational, measuring, monitoring, medical or control instrument, including any device listed in Schedule 7, but not including any implanted or infected medical instrument. O. Reg. 393/04, s. 1.