Managing Information Technology Waste in the Regional Municipality of Waterloo

by

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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

Information technology (IT) is one of the fastest growing product groups on the market today (Babu et al., 2006). This technology has become inexpensive to produce and continues to improve in the areas of memory, speed, operating systems, weight, and audio/visual capabilities (Envirosris, 2000). All of these factors have led to a decrease in product lifespan and an increase in the amount of IT-waste produced. IT-waste contains a number of hazardous materials. If this waste is not managed appropriately it can create serious environmental and human health problems. In Canada, there are no federal policies in place to manage IT-waste. Management of IT-waste has largely been the responsibility of local governments. Consequently, there is no uniformity. A wide spectrum of management approaches ranges from 'do nothing' to enacting bans to prohibit this waste from entering landfills. Recently (April 1, 2009), a program (Ontario Electronic Stewardship Waste Electronic and Electrical Equipment- OES WEEE) has been created at the provincial level to help with IT management. Residential participation in this program remains voluntary.

This research is exploratory and aims at examining the potential for a sustainable integrated waste management (IWM) plan for residential IT-waste, using the Regional Municipality of Waterloo (RMoW) as a case study. A multiple methods approach was employed to gain an understanding of IT-waste issues and to develop a set of sustainable IWM criteria for evaluation of the OES program and RMoW. Methods used to collect data included: a literature review, surveys, plan analysis, direct observation, key informant interviews, and archival research. A number of recommendations apply specifically to

Waterloo Region. Others more broadly address local governments across Ontario for better management of residential IT-waste and other e-waste products.

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Glossary

3Rs— Reduce, reuse, and recycle (Tchobanoglous and Kreith, 2002)

Certification of Approval — "is a control document issued by the Ontario Ministry of Environment that sets out operating conditions for a waste management system or a waste disposal site under the authority of section 27 of the Environmental Protection Act" (OES, 2008a,163)

Disposal— material which can be sent for reuse, recycling, landfill or incineration (Sakia, et al., 1996)

Eco-effective approach— takes a holistic approach to understanding the product and the impacts it will have on the entire system to eliminate waste from the beginning (McDonough and Braungart, 2002)

Eco-efficient approaches — to minimize waste by using reduce, reuse and recycle strategies (McDonough and Braungart, 2002)

Electronic waste (e-waste) — product that has reached the end of its life and has either an electronic currents or electromagnetic field to power it (Babu, et al., 2007)

End of Life (EOL) — equipment that has reached the end of its useful life (Envirosris, 2000)

European Union or EU— created by intergovernmental treaties to allow for greater easy and consistency amongst different countries for trade, environmental and social standards, labor, and policy. Regulations and directives are used to gain compliancy with the 27 member states (University of Massachusetts Lowell, 2006).

Final disposal— "entails the process of incineration (with or without energy recovery) or landfill" (Jofre and Morioka, 2005, 25)

First life— "refers to the amount of time a product is useful to its original owner and total lifespan is the period from manufacture to disposal" (Envirosris, 2000, 2-1)

Free Riders— "producers or importers who sell electrical and electronic equipment but do not live up to their take back obligations regarding WEEE" (United Nations University, 2008, 251)

Incinerate— thermally downgrading waste materials through burning or combustion (Tchobanoglous and Kreith, 2002)

Integrated Waste Management (IWM) — "a framework of reference for designing and implementing new waste management systems and for analysis and optimizing existing systems" (Seadon, 2006, 1327)

IT -waste— technology that uses a source of power in order to acquire information which includes any type of PCs, monitors, printers, keyboards, CD-ROM and disk drives that is no longer wanted (Nakajima, and Vanderburg, 2005).

Landfill— disposing solid waste in small layers across a designated area so it can be compacted (Tchobanoglous and Kreith, 2002)

Leachate— "liquid that has percolated through solid waste or another medium and has extracted, dissolved, or suspected materials from it, which may include potentially harmful materials" (Tchobanoglous and Kreith, 2002, , A.9)

Obsolete— equipment that is still useable but is considered no longer able to meet needs of the user: it represents the end of the equipment's first life (Envirosris, 2000)

Organization for Economic Co-Operation and Development (OECD) — It is an international organization made up of 30 countries (Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherland, New Zealand, Norway, Poland, Portugal, Slovak Republic, Span, Sweden, Switzerland, Turkey, United Kingdom, and United States) that follow a representative democracy and free market economy (Organization for Economic Co-Operation and Development, 2009)

Orphan waste— "EEE supplied in Ontario where the brand owner, first importer or assembler of these products is no longer conducting business in Ontario or whose brands, assets or liabilities have not been acquired by another company that is obligated under the program" (OES, 2008a, 23)

Preventative approach— the drive to avoid producing waste throughout the entire life of a product (Sakai et al., 1996).

Recovery— "The amount of processed materials or energy recovered for productive use from collected WEEE" (CSR et al., 2005).

Recycle— "includes the treatment, recovery, and reprocessing of materials contained in used products or components in order to replace virgin materials in the production of new goods" (Jofre and Morioka, 2005, 25)

Reduce— the process of diminishing the amount of waste generated (Waste Management, 2008)

Reuse— "provision of functioning WEEE to another user for its original intended purpose, without hardware repair or modification, and where the reuse activities are limited to non-intrusive operation verification, cleaning,replacement of consumable items (such as batteries, toners, fusers, etc.)" (OES, 2008a, viii)

Refurbish— "is any disassembly of WEEE for the purpose of internal testing, troubleshooting or replacement or repair of non-functioning or obsolete parts (not including consumable items such as batteries, toners, fusers, etc.)" (OES, 2008a, viii)

Source— where the waste is produced

Sustainability— "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, 43)

Waste Electronic and electrical equipment (WEEE) — product that has reached the end of its life and has either an electronic currents or electromagnetic field to power it (Babu, et al., 2007)

List of Acronyms

E-waste	Electronic waste
EOL	End of life
EU	European Union
GDP	Gross domestic product
IC&I	Industrial, commercial, and institutional
ICT	Information communication technology
IT-waste	Information technology waste
IWM	Integrated waste management
OECD	Organization for Economic Co-Operation and Development
OES	Ontario Electronic Stewardship
P&E	Promotion and Education
PBDD	Polybrominated dibenzodioxins
PBDF	Polybrominated dibenzofurans
RMoW	Regional Municipality of Waterloo
RoHS	Restriction of Hazardous Substances
WDA	Waste Diversion Act
WDO	Waste Diversion Ontario
WEEE	Waste electronic and electrical equipment

Chapter 1: Introduction

1.1 Background

In the 1950's computers were enormous, expensive, and scarce, while today's computers are compact, inexpensive, and abundant (Grossman, 2006). Technological progression has made individual access to electronic devices the norm. Manufacturers flood the markets every 12 to 18 months with new products (Grossman, 2006). Rapid technological succession has created a decreased lifespan and an increased disposal rate for electronic products (Babu et al., 2007; Lee et al., 2007; Saphores et al., 2006). While electronic devices provide convenience and utility, they have also created environmental problems, especially with respect to the end life of electronic equipment (Crede, 1995).

In the industrialized world, electronic waste (e-waste) has been identified as the fastest growing material in the waste stream at 4% growth per year (Wong et al., 2007). Further, an estimated 50% - 80% of all collected e-waste from industrialized countries is exported to "recycling centers" in China, India, Pakistan, Vietnam, and the Philippines, in order to take advantage of low labor costs and minimal environmental regulations (Ahluwalia and Nema, 2007; UNEP, 2005; et al., 2007). Environmental and human health hazards exist when recycling processes use unskilled laborers and primitive techniques (Ahluwalia and Nema, 2007). E-waste that is not recycled may be sent to landfills, where it takes up valuable space. In addition, the toxicity of these materials has the potential to cause serious environmental impacts now and in the future both locally and globally (Schmidt, 2002; Wong et al., 2007).

Recently, e-waste has received attention because of the compounding issues associated with the end of life (EOL) electronic and electrical equipment. This awareness has led to the development and enactment of policies in some regions of the world (Jofre and Morioka, 2005). For example, the European Union (EU) instituted the Waste Electronic and Electrical Equipment (WEEE) Directive to manage all types of e-waste including information technology waste (IT-waste) (Appendix A and Appendix B). The EU WEEE requires all member states to achieve a 4kg/capita/year recovery rate for e-waste (Envirosris, 2001; Jofre and Morioka, 2005). To help gain compliance and participation in the program, fixed collection sites have been set up without disposal charges (Envirosris, 2001).

In countries such as Canada, voluntary approaches for e-waste management are being employed thus far. There are no federal policies in place, but rather programs have been enacted at the provincial and municipal levels. Decisions about establishing e-waste programs are left to the discretion of local municipalities. Issues such as convenience, space availability, budget, and seasonal impact are all factors influencing whether or not a municipality will decide to implement an e-waste program (OES, 2008c). Since municipal programs are limited in scope, resources are typically not fully available to develop a solid infrastructure to collect and process e-waste. Further the lifespan of these voluntary initiatives is often uncertain. Of the 192 Ontario municipalities that responded to a 2004 survey, 42 (21.8%) would not continue their WEEE program the following year, 52 (27.2%) were uncertain, 16 (8.3%) would continue their program and 82 (42.7) did not respond to the question (CSR et al, 2005). The findings from this survey suggest lack of commitment or constrained resources or both among Ontario municipalities. To encourage action, the

province of Ontario passed Regulation 393/04 in 2004 as a voluntary provincial program to provide all residents an opportunity to recycle their EOL e-waste products. The introduction of this voluntary program, however, still means that there is nothing preventing residents from sending e-waste to landfills or incinerators (OES, 2008c).

1.2 Rationale and Purpose

In North America there are no national e-waste programs in place. In 2003 it was estimated that 70,000 tonnes of e-waste were disposed of in Canada alone (Waterloo Waste Management, 2004). A portion of this material was identified as IT-waste which is a component of e-waste and includes any product associated with the computer (see Appendix B) (Nakajima, and Vanderburg, 2005). Data show that IT-waste has continued to grow exponentially as more products have entered the market with progressively shorter life expectancies (Waterloo Waste Management, 2004; Babu et al., 2006).

IT-waste is of particular importance not only because it has a short first life-span, but also because it contains numerous materials including: plastics, lead, aluminum, gallium, nickel, vanadium, beryllium, chromium, cadmium, mercury, arsenic, and silica. These materials are associated with a wide range of detrimental human health effects ranging from skin irritation to brain, kidney, and lung damage (Grossman, 2006; Five Winds International, 2001; Schmidt, 2002). IT-waste incineration can release toxic emissions into the air. Landfilling has the potential for heavy metals to leach into both groundwater and the soil (Five Winds International, 2001; Grossman, 2006). In 1999 it was estimated that 34,000 tonnes of IT equipment were disposed of in Canada. This number has only continued to grow (Envirosris, 2001). Although numerous studies have been completed with regards to the

management of e-waste in Ontario, they provide no specific action plan at the municipal level (CSR et al, 2005; Envirosris, 2000; Envirosris, 2001; Five Winds International, 2001; Ontario Ministry of the Environment, 2007; WDO, 2005).

The main research question for this study is:

> *How might an integrated waste management (IWM) plan be developed in the Regional Municipality of Waterloo (RMoW) that best manages information technology (IT) waste at the residential level?*

It is also the intent of this research to address the following sub-questions:

- What are the key criteria for a sustainable IWM plan for managing IT-waste?
- What recommendations can be made for improving Waterloo's management of IT-waste drawing on experiences with initiatives elsewhere?
- How useful are the criteria in assessing current management of IT-waste in the Region of Waterloo?
- Can the analysis and recommendation be of assistance to other Ontario municipalities for managing IT-waste?

In 2004, Ontario's Ministry of the Environment examined how e-waste was being managed at that time. Findings from a 2005 report indicate that municipal and non-municipal programs have not been fully implemented (CSR et al., 2005). For example in 2004, only 2% of the 1.5 million computers and pieces of computer equipment discarded were diverted from landfills (Ontario Ministry of the Environment, 2007).

The purpose of this research is to first, evaluate the current system for managing residential IT-waste in the RMoW and second, to develop an integrated waste management (IWM) plan for sustainable management of IT-waste. Residential IT-waste was selected because it is more likely than any other sector to dispose of IT-waste directly into the regular

waste stream (Envirosris, 2001). Limiting the research to a focus on IT-waste provides an opportunity to rigorously investigate the specific operations associated with IT-waste. Conceptually the waste management hierarchy (Gertsakis and Lewis, 2003), IWM (Seadon, 2006), cradle to cradle (McDonough and Braungart, 2002) and Gibson's sustainability principles (Gibson et al., 2005) were integrated together to form a set of criteria to evaluate the Region of Waterloo management of IT-waste.

1.3 Criteria for Selecting RMoW

RMoW was chosen as the preferred study site for several reasons. First, it has a reputation for taking a progressive stance on waste management issues. Kitchener launched the first blue box program on September 17, 1981 which was subsequently used as a model all over the world (Recycling Product News, 2006). Second, the information-oriented industries and universities in the area generate significant amounts of IT-waste. Third, the Region implemented an e-waste ban in 2005. This action suggests that some resources (space, finances, and time) are already dedicated to management of IT-waste. Fourth, the Region includes both rural and urban areas, providing different perspectives on managing IT-waste. Finally, the Region's established interest in searching for new and better ways to handle IT-waste provides a positive and supportive environment for this research (personal conversation, 2009).

1.4 Criteria for Chosen Product

Municipalities are responsible for the management of residential waste. Each municipality must create its own waste management program that meets the needs of the area while also complying with provincial regulations (Jofre and Morioka, 2005). E-waste is only

one component in the municipal waste management system. However, for this study the researcher decided to just focus on IT-waste for several reasons. Examining one category of e-waste allows the researcher to engage in a more in-depth study. Second, IT is one of the fastest growing categories of products on the market today (Babu et al., 2006). Third, the lifespan of IT equipment continues to decrease because of continuous technological advancements (Babu et al., 2007; Kang and Schoeming, 2005). Fourth, hazardous materials found in IT equipment create waste management problems (Envirosris, 2001). Finally, the province of Ontario has only recently started to address the issues surrounding IT-waste management (OES, 2008c).

1.5 Target Audience

The target audience for this thesis is municipal waste managers, electronic recyclers and refurbishes, government officials, and those in the electronic industry/manufacturers. These three sectors influence the handling, decision-making, or creation of IT products.

1.6 Thesis Organization

The thesis is comprised of ten chapters: introduction; conceptual framework; methodology; literature review; European 5 case analysis; Ontario Electronic Stewardship WEEE program plan analysis; RMoW case study results; Ontario experience with IT-waste: results from interviews and surveys; discussion and recommendations; and conclusion. The conceptual framework explains the different concepts that directed the research. The methodology section describes the different methods used to collect the data. The literature review examined three themes: 1) e-waste and IT-waste characteristics 2) options for managing IT-waste; and 3) responsibility for managing IT-waste. The 5 European case

analyses provided different examples of other countries e-waste programs and helped with the development of the criteria. A plan analysis of the Ontario WEEE program was done using the created criteria to identify any issues with the new program. Results from the case study provided specific information about IT-management in the RMoW. Results from other municipalities identified how other municipalities were handling IT-waste. The discussion focuses on the implication of the results and provided recommendations for the development of an IWM for IT-waste in Waterloo Region and other areas in Ontario. The final chapter was a review of responses to the research questions. Further research contributions, the limitations of the research, and suggestions for future research should head towards are identified.

Chapter 2: Conceptual Framework.

2.1 Background

The conceptual framework draws upon waste management, product design and sustainability. Key waste management concepts include the waste management hierarchy (Gertsakis and Lewis, 2003) and IWM (Seadon, 2006) which offers different analytical options for handling waste. The cradle to cradle approach tries to eliminate waste altogether by changing product design. The sustainability framework (Gibson et al., 2005) provides a theoretical tool to support decision-making. Incorporating characteristics from each domain provides a useful lens for examining IT-waste management now and in the future (see figure 2.1).

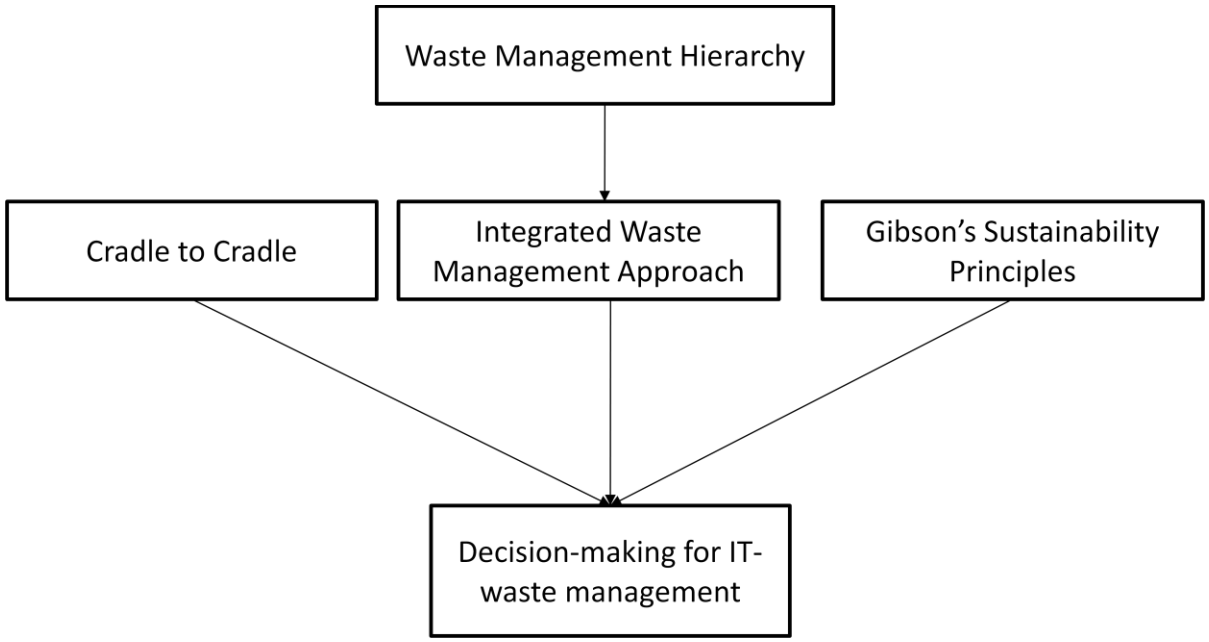

Figure 2.1: The conceptual framework employed in this research project

2.2 Waste Management Hierarchy

The waste management hierarchy was introduced in the 1970's. Many industrialized nations have used the hierarchy as a tool in the development of municipal solid waste systems (Sakai et al., 1996). Waste is a heterogeneous material. Different treatment options are required in order for waste minimization to occur. (Gertsakis and Lewis, 2003). The aim of the hierarchy is to continue to use resources in order to minimize the amount of waste generated (Gertsakis and Lewis, 2003; Wilson, 2007). Concepts of sustainability and the precautionary principle (preventative action should be taken when it comes to decision-making) provide a frame for implementation to ensure that any discarded product has the least possible negative impact from an environmental, social, and economical perspective (Gertsakis and Lewis, 2003).

The waste management hierarchy is used to prioritize (refuse or prevent, reduce, reuse, recycle, energy recovery and final disposal) waste practices that have least adverse environmental impacts. The hierarchy first advocates eliminating as much waste from the source as possible in order to decrease the chances of infections and contamination from hazardous waste. Second option is to reduce, re-use, and recycle materials sent for disposal. Although waste is still generated it minimizes the amount sent to the landfill or incinerator. Third choice is to turn waste into energy when the above options have been fully exhausted. Creating this energy is expensive and requires waste to be incinerated which can result in air quality problem. The least preferred option is to send it to the landfill where it stays indefinitely and takes up space. The rationale for this hierarchy is that the closer one moves towards final disposal options, the more risk there is with managing waste (see figure 2.2)

(Cheremisinoff, 2003). The waste management hierarchy provides a template for decision-making regarding alternative actions for the management of waste.

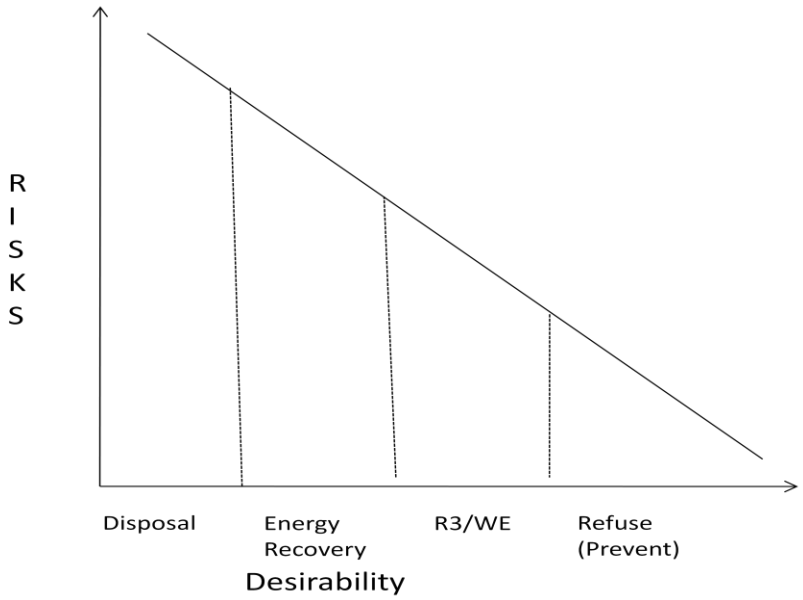

Figure 2.2 Waste management strategies examining risk against desirability (modified from Cheremisinoff, 2003)

2.2.1 Critiques

White et al. (1995) indicate that rigidity within the hierarchy may lead to continual reliance on the historically preferred choices. For example, old IT equipment is frequently sent to developing nations for re-use. The second life of this equipment is often short lived and soon becomes part of the waste stream. In the end, total negative environmental impacts may be greater for this reuse option because of additional resources needed for transportation, as compared to initial recycling (UNEP, 2005). McDougall and Hruska (2000) also argue that there is no scientific evidence to suggest that the hierarchy ranking of options is correct (see figure 2.2). Secondly they suggest that the hierarchy does not take into consideration multiple treatment options with respect to waste handling. Finally, it does not

consider cost nor address “unusual” circumstances such as handling waste in areas of low populations or isolated areas. Recognition of these issues is imperative in taking the necessary steps to avoid these problematic areas.

2.3 Cradle to Cradle

The cradle to cradle concept integrates a zero waste philosophy into product design. It goes a step beyond more conventional ‘cradle to grave’ waste management planning. Instead, it focuses on reduction or elimination at source through environmentally effective approaches to product design (McDonough and Braungart, 2002).

2.3.1 Current Model of Management

The market is designed in a linear system where products are created, sold, used and eventually discarded —a cradle-to-grave model. “Many products are designed with built-in obsolescence to last only for a certain period of time— to encourage the consumer to get rid of the thing and buy a new model” (McDonough and Braungart, 2002, pg. 28). These authors suggest that our current paradigm of manufacturing is the result of a number of factors, including:

- One size fits all— employing universal designs instead of designs based on a particular condition
- Brute force— imposing designs that do not fit the circumstances
- Culture of monoculture—accepting the quickest and easiest solution without considering alternative approaches
- Activity equals prosperity— activity leads to economic growth which may also have long term consequences on the ecological, social, and cultural impacts
- Crude products—products which do not consider the ecological and human health impacts

The proposed solution is to take an eco-efficient approach based on the 4R's (reduce, reuse, recycle and recover) to minimize the impact from humans design failures (McDonough and Braungart, 2002). Eco-efficiency takes a reactionary approach to reduce the impact without actually going to the source and eliminating the problem all together (Braugart, McDonough, and Bollinger, 2006).

2.3.2 Moving Towards Eco-effectiveness

An eco-effective approach to design takes a holistic approach to understanding products and the impacts they will have on entire systems. To eliminate waste, design needs to take into account:

1. Biological metabolism— managed through the natural cycle. Products are able to decompose and bring nutrient to the land once they are no longer needed.
2. Technical metabolism— managed through the industrial cycle. Products are not disposed of but rather are disassembled and used to create new products.

Technical metabolism ensures that materials are not down-cycled but rather kept in their original material state. The material value is not lost but rather stays at the same quality. For example, "a sturdy computer case will continually circulate as a sturdy plastic computer case—or as some other high quality product, like a car part or a medical device— instead of being downcycled into soundproof barriers or flowerpots" (McDonough and Braungart, 2002, pg. 110). Furthermore, McDonough and Braungart (2002) suggest that instead of buying products, consumers should consider that they buy services. When they are finished with using a product, manufacturers should take back their products and modify them to meet current needs (McDonough and Braungart, 2002).

2.4 Integrated Waste Management (IWM)

IWM considers the direct impacts (transportation, collection, and treatment) a product has at its end-life and the indirect impacts (energy, water and waste used in the development and use) it has throughout its entire life (Seadon, 2006; White et al., 1995). IWM concept provides a flexible frame of reference for building on existing waste management systems or developing new systems (Seadon, 2006). IWM seeks to predict long-term trends in order to develop effective waste management programs (Huang et al., 1997). The IWM approach examines individual waste problems holistically by identifying the inter-relationships between different components (Seadon, 2006). The success of IWM ultimately depends on commitment, communication and collaboration from different stakeholders involved (government, non-government, public, private, etc.) and the implementation of various tools (regulatory, economic, voluntary, and informational devices) in order for waste to be managed for optimal economical, environmental, and social sustainability (Seadon, 2006).

2.4.1 Stakeholders and Tools

A stakeholder is anyone who is affected by the proposed IWM system including but not limited to: governmental bodies, local community members, non-government organizations, and industry. It is vital that these players be included in the planning and decision process since the success or failure of an IWM program ultimately rests in their hands. Regulatory, economic, voluntary, and informational devices are the tools used in IWM (Seadon, 2006). Stakeholder responsibility is influenced depending on what tool (regulatory, economic, voluntary, and informational devices) is used. Regulatory and economic instruments are often government selected and force compliance. The intention is

to require producers to comply with certain standards as they relate to the manufacturing of a product.

Industries prefer a voluntary approach so that they do not have to manage constraints placed on them by governmental regulations. Voluntary programs can also include lobbying to change people's behaviors to be more environmentally conscious (Seadon, 2006).

Implementation of IWM plans requires the support of different stakeholders and tools. It may create a more complicated and time-consuming decision process compared to systems relying on the waste management hierarchy. Proponents of IWM agree that the long-term benefits of less expense, easier maintenance, and reduced environmental and social impacts compensates for higher initial setup costs (Seadon, 2006).

2.5 Gibson's Sustainability Principles

Sustainability processes require analysis of each situation in order to make well-informed decisions. For this study sustainability will be defined as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, 43). This study relies on the eight principles Gibson et al. (2005, 95-120) identified as essential for sustainable decision-making:

1. Socio-ecological system integrity ―establish and preserve a long-standing relationship between humans and their ecological systems to ensure integrity of the biophysical system is being maintained
2. Livelihood sufficiency and opportunity ―ensure that all individuals have access to an adequate standard of living and have the power to improve their livelihood without compromising future generations

3. Intragenerational equity— ensure that choices and actions made today will minimize the gap in sufficiency and opportunity between the rich and poor
4. Intergenerational equity— ensures choices and actions made today will maintain or improve future generations livelihood
5. Resource maintenance and efficiency— ensure resource viability by reducing actions that have damaging consequences on the environment now and in the future
6. Socio-ecological civility and democratic governance —ensure that decision-making is transparent and that all individuals have a say in actions made
7. Precaution and adaptation —ensure comprehensive understanding of the action before a decision is made and if there is any uncertainty avoid implementation altogether
8. Immediate and long-term integration — all principles must be applied at the same time to move towards sustainability

Each principle can be considered as a separate concept which can provide a different evaluation tool to assess the various aspects associated with waste issues. Together these principles can move society towards a sustainable future. For this study, each principle provides one component of a general guide for assessing how to create a sustainable IWM plan for the management of IT-waste (see Chapter 5, Section 5.4).

2.6 Framework Assumptions

A number of assumptions are associated with the above conceptual framework. First, the RMoW is not managing its IT-waste optimally. Second, IWM is a desirable approach for dealing with IT-waste situation. Third, a positive future direction will be towards eliminating waste through the disassembly and remanufacturing of IT equipment. Finally, employing

Gibson's eight principles of sustainability will promote, well-informed decision making for enhanced sustainability.

2.7 Conclusion

The purpose of this research is to provide the RMoW with a sustainable IWM plan for managing IT-waste now and in the future. The waste management hierarchy was chosen because it has been identified as a model of choice (Ahluwalia, and Nema, 2007; Gertsakis and Lewis, 2003; White et al., 1995). Although problems have been identified with this concept it is still the preferred approach for developing a waste management program for already existing waste (Sakai et al., 1996). It is a prescriptive tool providing recommendations for using alternative options such as reduce, reuse, recycle, and recovery before relying on a final disposal option (Gertsakis and Lewis, 2003; Wilson, 2007). It takes a downstream approach (deals with the situation once it presents itself) to managing waste which already exists. The cradle to cradle approach takes an upstream approach (trying to prevent the situation from the beginning) by looking at the design of the product to eliminate the waste problem altogether. IWM integrates both of these concepts together by examining the entire system (McDougall et al., 2001; Seadon, 2006). IWM recognizes that a single approach cannot and will not provide the best solutions for managing waste. The entire waste process must be examined to determine where problems exist in order to create solutions. Solutions are based on what operations are most sustainable (White et al., 1995). However, defining what sustainability means can be complicated. Gibson's sustainability principles provide a guide to developing a comprehensive frame for analysis to decision-making (Gibson et al., 2005). Integrating Gibson's sustainability principles with waste management

hierarchy, cradle to cradle, and IWM concepts led to the development of sustainable IWM principles (see table 2.1)

Table 2.1 Sustainable IWM principles

Sustainability Principles Decision-making (adopted from Gibson et al., 2005)	**Sustainable IWM** Management options (adopted from Gertsakis and Lewis, 2003; McDonough and Braungart, 2002; Seadon, 2006).
Socio-ecological system integrity— establish and preserve a long standing relationship between humans and their ecological systems to ensure integrity of the biophysical system is being maintained	Decisions which results in the least impact on the social and ecological system with the management of a product from design to disposal
Livelihood sufficiency and opportunity— ensure that all individuals have access to an adequate standard of living and have the power to improve their livelihood without compromising future generations	Continue to improve product management to ensure that the safety and wellbeing of individuals are not compromised now and in the future
Intragenerational equity— ensure that choices and actions made today will minimize the gap in sufficiency and opportunity between the rich and poor	Consider the impacts decisions and actions have on the disposal of a product and on the health and safety of those involved in its end life management
Intergenerational equity—ensures choices and actions made today will maintain or improve future generations livelihood	Considers the effects decisions and actions have on product design in order to eliminate damaging impacts that will affect future generations at its end-life
Resource maintenance and efficiency — ensure resource viability by reducing actions that have damaging consequences on the environment now and in the future	Design product with the least amount of impact by considering material composition and end of life disposal options through the integration of the cradle to cradle design principles
Socio-ecological civility and democratic governance— ensure that decision-making is transparent and that all individuals have a say in actions made	All stakeholders are informed and have equal opportunity in decision making regarding the management of a product and available services
Precaution and adaptation—ensure	Prevent unfavorable outcomes with the

comprehensive understanding of the action before a decision is made and if there is any uncertainty avoid implementation altogether	disposal of a product by having incentives/disincentives in place
Immediate and long-term integration — all principles must be applied at the same time to move towards sustainability	Universal commitment when it comes to the management of a product from production to disposal

Chapter 3: Methodology

3.1 Research Design and Overview

Although problems associated with information technology (IT) waste have been well identified, adequate solutions have yet to be found. Accordingly, the research design of this study is exploratory. This approach allows the investigator to extrapolate information from secondary sources as well as to rely on a variety of qualitative approaches to gather primary data (Palys, 2003). As with any type of research design, there are limitations. The exploratory approach has been criticized on the basis that qualitative data are open to subjective interpretation, leading to biases in the results that are reported (Leedy, 1993; Palys, 2003). Triangulation was used to address these issues as well as to ensure that the information gathered was both reliable and valid (Palys, 2003). Literature review, surveys, plan analysis, interviews, and case study—direct observation, key informant interviews, review of documentation and archival research, were methods employed. This multi-method approach assisted in ensuring that a holistic understanding of the research question was considered. (Atkinson and Coffey, 2002; Yin, 2003).

3.2 Methodological Framework

A five-phase framework was developed to organize and collect data needed to achieve the end goal of examining the potential for a sustainable integrated waste management (IWM) plan for IT-waste in the Regional Municipality of Waterloo (RMoW). A multi-method approach was employed to check consistency across the data being reported from the different methods employed (Flowerdew, 2005). Table 3.1 shows the different phases used to answer the research question. The first phase involved identifying and defining the research

question and objectives, and included an initial review of the literature and discussions with professionals in the waste management field.

The focus of the second phase was to understand the theoretical base for an integrated waste management plan. Waste management and design concepts were researched and reviewed through a literature review. The result was the development of a sustainable integrated waste management (IWM) framework.

The third phase of the project was twofold: first, a broad examination of the IT-waste situation, including identifying and analyzing areas in Europe that have e-waste management programs in place; second the development of a set of criteria for sustainable IWM of IT-waste. The criteria were developed to be used as an assessment tool.

The fourth phase involved using the criteria to evaluate the Ontario Electronic Stewardship (OES) WEEE program plan and the RMoW management of IT-waste. Key informant interviews were held with a number of experts including waste managers from the RMoW, waste managers from other regions, independent recycle and reuse companies, and RMoW council members. All of these individuals had expertise with certain aspects associated with development, decision-making, handling, or disposal of IT products.

The fifth and final phase of the project was the creation of recommendations for a sustainable IWM plan for IT-waste in the RMoW and Ontario. The recommendations were generated from the data gathered from the different methods employed. Identification of where future research should head was also stated within this phase.

Table 3.1 Methodological framework used for the research project

Phases	Action/method	Outcome
Phase 1: Identification of problem	Review of literature Discussions with professionals	Research questions Selected case study
Phase 2: Understand the different options associated with waste management	Review of literature	Conceptual framework
Phase 3: Examine current barriers and actions with IT-waste management	Review of literature Review of European WEEE programs	Development of criteria
Phase 4: Evaluate criteria against OES program and case study	Analysis of OES program Documentation Archival records Interviews/surveys Observations	Evaluation of OES program and case study
Phase 5: Recommendations and feedback	Written report	Recommendations for the case study Expansion of findings to other areas Identification where further research is needed

3.3 Literature Review

3.3.1 Purpose

Specific attention was given to the different disposal options for IT-waste; what European countries were doing with their obsolete IT-waste; what is currently taking place in Ontario with respect to the management of IT-waste; and commonly cited issues associated with IT-waste programs. The literature review helped provide background information and assisted in the development of the conceptual framework and criteria.

3.3.2 Design

The literature came from primary and secondary sources including academic journal articles, government reports, books, research books, and internet sources. The sources were found using key word searches such as: integrated waste management, electronic waste, waste electrical and electronic equipment (WEEE), information technology, waste management hierarchy, sustainability, cradle to cradle, waste management, Ontario, regulatory initiative, voluntary initiative, producer responsibility, WEEE Directive, and consumer responsibility. These keyword searches provided the necessary information needed to carry out the latter steps of the research. Each source of literature provided specific information. Data and information regarding e-waste programs came from many government reports found on the internet. Journal articles identified many of the issues associated with IT-waste. Company websites provided details about different organization initiatives with IT management. Finally books were used to learn about the different concepts employed in this thesis.

3.3.3 Benefits and Limitations

As a check on the quality of information obtained, benefits and limitations are assessed for each source used. For example, peer reviewed journal articles go through rigorous evaluation by experts in the field before they are published, but there are not many articles pertaining specifically to IT-waste in Ontario. Government reports filled some of the missing gaps, but there is the potential for bias because they have not been peer reviewed. A particular deficiency with these documents was in reporting the types of methods used to obtain the data presented. With non-governmental internet sources, caution must be

exercised since there are no controls on online post ups. Developing a set of criteria which identified questionable sources is essential; in order to ensure the information collected is reputable (Booth et al, 2003). For this study, information meeting at least three of the following criteria was deemed acceptable: information reported is found in multiple sources; it contains a work cited page; the author's name and date are given; there appears to be no personal biases in the information presented (Beck, 1997).

3.4 Plan Analysis

3.4.1 Purpose

A review of *Waste Electrical and Electronic Equipment Program Plan* was used to analyze the utility of the newly approved Ontario WEEE program (OES, 2008a). The review helped to determine the utility of the program with respect to sustainably managing IT-waste at the municipal level.

3.4.2 Design

The Ontario WEEE program plan was analyzed using criteria developed from the conceptual framework and the literature review. The review also tried to identify information which was absent from the report.

3.4.3 Benefits and Limitations

The review had a number of positive benefits associated with its use. It provided specific information regarding names, dates, and events and could be reviewed multiple times. It allows the researcher to evaluate the OES program against the created criteria. Finally, it provided the researcher with insight into what has already been examined in this

area of study and where further information is needed. The limitations with this plan analysis were the lack of data and use of only one document to analyze the program (Palys, 2003 and Yin, 2003).

3.5 Interviews and Surveys

3.5.1 Purpose

Thirty-eight waste managers from different municipalities, townships, and cities across Ontario were either interviewed or surveyed. The purpose was to identify both favorable and unfavorable approaches to IT-waste management. In addition as part of the case study in Waterloo Region (see section 3.6), 13 local interviews were carried out.

3.5.2 Design

Semi-structured interviews were conducted with 3 different regional municipal waste managers and 1 city waste manager for roughly 30 minutes each during the end of September and beginning of October 2008. Three of the interviews were carried out over the phone and one was done face-to-face. These individuals were selected because they either had a similar government system in place as Waterloo Region or had been identified as taking progressive initiatives with the management of their IT-waste. With the interviewees' consent, the interviews were audio recorded and transcribed for analysis. A transcript of the interview was emailed to allow the interviewee an opportunity to confirm the accuracy of the conversation and to add or clarify any points they wished.

A shorter modified version of the interview questions were given to 55 municipalities in the form of a six-question survey during the week of November 19, 2008. These

municipalities were selected because they were identified by Waste Diversion Ontario as having collected e-waste in 2006 (WDO, 2007b). These entities were contacted by email (46) or by phone (9—if there was no email address) to answer a survey regarding their waste electrical and electronic equipment (WEEE) programs. After one week, a second email went out to all the municipalities who had not responded previously to obtain a higher response rate. Emailing was the method of choice for distributing the surveys because of ease, cost, time, and convenience. Identical questions were used on both forms of data collection. Responses came from 34 municipalities, townships, and cities (a 61.8% response rate).

3.5.3 Benefits and Limitations

Semi-structured interviews allowed for a detail discussion to take place with waste managers. Interviews allowed the researcher to ask for clarification to responses and the opportunity to probe for more information when interesting comments were raised. Three out of the 4 interviews were done over the phone because the interviewees felt that was the most convenient option. However, only 4 waste managers agreed to participate in a semi-structured interview out of 8. The reasons cited for non-participation were the amount of time and the sensitivity of the information. E-mail and telephone surveys were used in order to reach more waste mangers without require the time and money needed for interviews. Questions were not opinion based, but rather procedural and factual based to reduce any ambiguity issues. Although there was a 61% response rate, completion of all the questions in the e-mail survey was an issue. The last question in particular had a low response rate.

3.6 Case Study

3.6.1 Purpose

A case study provided an in-depth analysis of IT-waste management, with respect to types and quantities, cost, and public responsibility. A single case design approach was employed using the RMoW as the study site. The rationale for using a single case design was based upon selecting a site that has the reputation of 'exemplary.' The set of criteria developed through the literature review, were used to evaluate the case study and to develop recommendations.

3.6.2 Example of Case Studies from Other Research

Case studies can be tailored to a specific focus, depending on what information needs to be collected. Numerous studies, particularly those dealing with IWM strategies have relied on case studies as a major component of their research because multiple methods can be used to gather information (Palmeres 2000, Su and Wang 2003; Ahluwalia and Nema, 2007). For example, Huang et al. (1997) used a single case design (municipality of Hamilton-Wentworth located in Ontario, Canada) to study capacity planning for an IWM system. It relied upon documentation and archival records to provide the necessary information – operational cost, waste management facility, types and quantities of waste, affected population, and waste program – to formulate the most appropriate plan of action. Zhang and Roberts (2007) used a multi-case design to evaluate how well integrated industrial waste management promotes urban sustainable development. It too relied upon documentation and archival records, as well as questionnaires and semi-structure interviews. These examples illustrate the potential of case studies. For this research a four method (documentation, archival records, semi-

structured interviews, and observations) approach was used to gain a holistic sense of the IT-waste situation from a financial, environmental, political, and social perspective.

3.6.3 Benefits and Limitations

Four major strengths have been identified in the literature with case study designs. First, they are restrictive in nature, allowing for greater understanding of the complex inter-relationships of the item(s) to be studied. Second, they are based on real time with no controls in place to inhibit interference from the outside elements. With experiments, interference is purposely avoided. However, the exclusion of this noise can result in failure to have a comprehensive understanding of the issues under study. Third, they can lead to unexpected and unusual results which could not be obtained from other methodological approaches. Fourth, the flexibility associated with a case study allows the researcher to address issues as they emerge (Hodkinson and Hodkinson, 2001).

Three known weaknesses of case studies are relevant here. First, there is a large volume of data that is collected and most of it is qualitative in nature which has the potential to lead to subjectivity problems. More specifically, personal interpretation of design accompanied with collection and evaluation can lead to biases in what is reported. Second, they can be time consuming especially with all of the different methods employed. Finally, there is the issue of generalization. The results from one particular case study cannot be generalized to the entire population. However, the findings can be transformed into theoretical propositions (Hodkinson and Hodkinson, 2001; Yin, 2003).

It is important not only identify the benefits and limitations of case studies, but also with the methods chosen for the case study (see table 3.2). Using a multi-method approach

helps to ensure that a holistic understanding is developed and that the data collected is reliable and valid, providing a basis for developing useful recommendations.

Table 3.2 Benefits and limitations of different types of methods used in a case study

Method	Benefits	Limitations	Source
Documentation	-has the ability to be reviewed multiple times -precise information with regards to names, dates, events -exists prior to case study -examines long term trends	-may be difficult to obtain due to sensitivity issues -reporting biases -biases in selectivity -data not tailored to this research	Palys, 2003 Pelham and Blanton, 2003 Yin, 2003
Archival records	-quantitative data -has the ability to be reviewed multiple times -precise information with regards to names, dates, events -high external validity -researcher cannot influence findings -examines long term trends	-may be difficult to obtain due to sensitivity issues -reporting biases -data not tailored to this research	Palys, 2003 Pelham and Blanton, 2003 Yin, 2003
Semi-structured interviews	-questions pertain to case study topic - higher rates of participation -opportunity to clarify information -allows for further probing	-response bias -incomplete recollection -timely -costly - respondent may tell interviewer what they think he/she wants to hear	Palys, 2003 Pelham and Blanton, 2003 Sproull, 1995 Yin, 2003
Direct observation	-real time coverage in natural environment	-time consuming - subjects are aware they are being observed and may change their behavior -observer bias	Sproull, 1995 Yin, 2003

3.6.4 Methods Employed for this Case Study

3.6.4.1 Document Review

Literature review provided essential context for this case study. Information examined included: characteristics of the population; waste management plans and programs initiated; bylaws and regulations that have been enacted; identification and responsibility associated with the different waste facilities located around the Region; and, costs associated with waste management. Much of the information came from regional documents such as the RMoW Waste Management Master Plan (Region of Waterloo, 2006), program reports, memoranda, and progress reports found on the Region's website (http://www.region.waterloo.on.ca/web/Region.nsf/8ef02c0fded0c82a85256e590071a3ce/5cd546d37033849785256b0400666515!OpenDocument). The review further helped to inform the design and the development of interview questions that were used in the latter phase of the study.

3.6.4.2 Archival Research

E-waste data and household numbers were used to identify growth in the amount of E-waste collected and diverted from the landfill. E-waste collection totals from other Regional Municipalities around Ontario were used as comparisons. All areas selected had to be a Regional Municipality, collect residential IT-waste, and have drop-off locations all year round.

3.6.4.3 Interviews

Thirteen semi-structured interviews were held with individuals who have a direct influence on waste management decisions in the RMoW or who play a role with the handling of IT-waste. Interviews were conducted with 2 RMoW waste management coordinators, 7 operators who worked in e-waste processing facilities, and 4 RMoW Council members during the months of March and April 2009. Waste managers and independent e-waste processing companies were interviewed to get a firsthand account of how IT products are handled and to hear opinions about what can be done to better manage IT-waste in the future. RMoW Council members provided information with respect to how waste management decisions are made. The purpose of these interviews was twofold: first to gain practical knowledge and insight into the current management of IT-waste in the region; second to determine whether the system in place for managing IT-waste is currently sustainable or if additional resources are required. Individuals who worked for the Ontario Ministry of the Environment (MOE) and Ontario Electronic Stewardship (OES) were also approached for interviewees. However, no interviews took place either because there was no response or the individual indicated they were too busy to participate in the research.

All interview questions were pre-tested with four different individuals. Questions asked were developed from the information obtained from documentation and archival research as well as from the literature review. The interviews lasted anywhere from 10 minutes up to 1 hour 20 minutes. Participants were asked some questions in common and some specific questions pertaining to their specialties. All interviews were recorded unless the participant requested no taping. Informal notes were also taken by the researcher. The

recorded interviews were then transcribed for coding and analysis. Coding was used as an analytical tool to identify themes, compare groups, and determine what was missed from what was said (Ryan and Bernard, 2000). A colour coding scheme was chosen.

3.6.4.4 Direct Observations

Observations were made by the researcher at the RMoW Waste Management facility small vehicle transfer station and at an e-waste processing facility. Observations took place on Monday March 2, 2009 and Tuesday March 24, 2009 for about 30 minutes at each facility. Employee actions were observed, work conditions were examined, and movement of IT-waste was monitored and recorded. Data collected were in the form of field notes which were written as open-ended narrative to maintain as much objectivity as possible (Angrosino and Mays de Perez, 2000). The purpose was to get a first-hand sense of what was taking place and to determine whether the data obtained from this method corresponds to the findings from the other methods of data collection (Palys 2003). One observation at each location was sufficient for this study since residential use was sporadic and the procedures for management were the same each time. Furthermore, during observation sessions at both facilities a guide was present and explained that what the researcher was observing was consistent with what normally takes place.

3.6.5 Evaluation Summary of Methods Employed

Four different methods were chosen for this case study. Each method provided its own unique perspective on the IT-waste situation. Data collected from archival records provided quantitative data. Documentation, interviews, and observations all provided qualitative findings. Each method offered different benefits and limitations to this case study.

The first method, documentation, provided the foundation for executing this case study. Documentation was able to identify the different initiatives (e-waste ban and e-waste directory) which have been implemented and the basic components (cost, location, and hours of operation) of the RMoW e-waste program. Although some of the documents were not current, the information was consistent with what was being observed and said by the interviewees.

The second method, archival records, provided e-waste collection totals specifically for the RMoW (WDO, 2007b). These totals only took into account the amount of e-waste collected by the RMoW and did not take into account the other avenues (manufacturers, OES program, and e-waste directory) of e-waste disposal. Therefore, these numbers were not an exact representation of e-waste diversion totals for the RMoW. What the data do provide is general trends in e-waste collection totals which can be applied to the IT-waste situation to make assumption about the future direction of IT-waste collection.

The third method, semi-structure interviews, provided personal opinions with respect to the IT-waste situation. The interviews allowed respondents to offer personal opinions which could not be obtained from any other source. It also allowed the researcher the opportunity to probe for more information when interesting comments were raised. For this study, the number of individuals who agreed to be interviewed was low. Furthermore, there was a broad spectrum in the responses received depending on the interviewee. Some participants were extremely detailed and forthcoming while others were not.

The fourth method, direct observations, provided firsthand accounts of what residents are required to do when disposing of IT-waste at the Region and at a private e-waste processing company. Each observation session allowed the researcher to determine whether the information obtained from other methods corresponded to what is actually taking place. However, a limitation was the number of observations that took place.

The various methods employed all provide specific information needed to answer the research question.

3.7 Methodological Challenges

There were several challenges that arose during this study. Obtaining reliable statistical data with regard to discarded IT-waste in the Waterloo Region was not easy. A report by CSR et al. (2005) has indicated that data in this area are particularly weak and usually based on estimations. An additional challenge is the ever evolving state of e-waste management in the province. The province of Ontario has currently implemented a new program for handling discarded e-waste equipment which may affect the role that RMoW has in the future management of IT-waste. Interviews with OES members and government officials could not be achieved because they were too busy with setting up the Ontario WEEE program. Finally, a single case study was used to test the criteria. As such, it may be difficult to make generalizations to other municipalities outside Ontario.

3.8 Ethical Considerations

Ethics clearance was received before the research began through the University of Waterloo Office of Research Ethics (ORE). Ethics clearance indicates that the researcher

satisfied the requirements with the University of Waterloo in order to be able to use human subjects in this research. They key concern of the ethics process is to ensure the safety and wellbeing of each research participant participating in the study.

Chapter 4: Literature Review

4.1 History of Waste Management

Waste and waste management have changed considerably throughout history as different drivers have led to various approaches to handle waste. Wilson (2007) believes that identifying and understanding these evolutionary drivers is vital for development of sustainable waste management systems. Numerous ways exist to classify waste including where it is produced (residential, agriculture and industrial) and what form (hazardous, solid, liquid, and gaseous) it takes (Kharbanda and Stallworthy, 1990; Seadon, 2006).

Cleanliness, health, and environmental protection are three key historic drivers influencing the evolution of waste management (Bilitewski et al., 1997; McDougall, F. and Hruska, 2000; Wilson, 2007). Cleanliness has influenced waste management decisions for centuries, and in numerous regions of the world (Bilitewski et al., 1997). Archeological work suggests that concern about cleanliness was first observed sometime around 8,000 to 9,000 B.C., when waste was sent outside settlements to avoid pest, odor, and wild animal issues. In Athens in 320 B.C., regulations insisted that streets were swept daily and waste was sent two kilometers beyond the city wall. In the Roman Empire, earthen urinals were placed in public places to contain human waste.

In the 1850s, public health concerns became a new driver for waste management decisions. Researchers believed that infectious diseases such as yellow fever, cholera, and typhoid were the result of decaying organic matter. New technologies such as the incinerator were developed in response (Bilitewski et al., 1997; McDougall and Hruska, 2000; Seadon, 2006; Tarr, 1985; Wilson, 2007).

In the 1970's environmental protection became a major driver. This led to the development of the waste management hierarchy and IWM. Both concepts continue to play key roles in today's waste management decisions and have provided one part of the theoretical framework for this study (Bilitewski et al., 1997; Wilson, 2007). McDonough and Braungart (2002) believe the future direction will be to move towards a zero waste society where products are design to be disassembled and reused over and over.

4.2 Electronic Waste (E-waste)

The manufacture of electronic equipment has become one of the largest growing industries in recent times. This shift has not only led to advancements in electronic technology and greater product availability, but it has also resulted in a new type of waste, e-waste (Hischier et al., 2005; Lee et al., 2007). Worldwide e-waste has been identified as one of the fastest growing components in today's waste stream, currently estimated at 8% of all municipal waste (Babu et al., 2007).

4.2.1 Definition of E-waste

E-waste has been described as any type of product using either electronic currents or an electromagnetic field to power it, which has reached the end of its life. As such, there are numerous categories of waste electronic and electrical equipment (WEEE): large and small household appliances, information technology equipment, telecommunication equipment, audio/visual equipment, lighting equipment, tools, toys, medical equipment, monitor and control instruments, and automatic dispensers (Babu et al., 2007). Any and all of these products have the potential to cause serious environmental and human health related problems both for today and the immediate future if they are not handled appropriately.

4.2.2 Issues Associated with E-waste

Electronic devices can create problems at the end of their functional lives if handled improperly (Babu et al., 2007). Every electronic device is composed of a variety of materials, some of which have been classified as hazardous (see table 4.2). All of these materials have the potential to create serious problems if they leak into the soil or ground water or escape into the atmosphere. This hazardous material is a significant concern if e-waste is landfilled or incinerated rather than recycled or re-used. Even with all of the known risks, more than 90% of WEEE worldwide is still landfilled presently (Babu et al., 2007: UNEP, 2005).

Recycling e-waste is in its early stage and as such there is a weak infrastructure in place for its management (Kang and Schoenung, 2005; UNEP, 2005). In a survey of 11e-waste processors in Ontario, six indicated that they did not handle hazardous waste although they also reported that they disassemble WEEE products containing hazardous materials (WDO, 2005). Results from the survey clearly showed that a lack of knowledge exists about e-waste management. Recycling of electronic products is largely unregulated in Canada. Limited technology is available to promote recycling e-waste and therefore, most recycling is done manually. This action not only takes time, but is also costly and can lead to health problems if employees are not provided with the appropriate training and equipment (Kang and Schoeming, 2005).

Electronic devices contain materials including plastics, metals, and glass that complicate recycling because separation must take place. The problem is magnified by the mixed composition of different electronic products used by various companies in the industry. Because each manufacturer has its own patents for its own products, there is no

consistency with regards to the type and purity of materials used, also creating greater problems for the efficient and effective disposal of e-waste (WDO, 2005).

People from developed countries send old equipment (8 years or older) to developing countries as an act of charity, for their re-use. Although re-using old electronic equipment increases the life span of the product, it also means that the developed countries no longer take responsibility for management of their e-waste (UNEP, 2005).

E-waste is also often exported to developing countries where it is supposedly recycled as a cost saving measure. It has been estimated that 50% of e-waste collected for recycling in the United States is actually outsourced to India, China, and Pakistan where elementary techniques are used for handling (Kang and Schoeming, 2005; UNEP, 2005). Studies have shown that these rudimentary recycling practices have led regions such as Guiyi, China to have higher concentrations of persistent organic pollutants (POPs) and heavy metals in comparison to the surrounding areas. These elevated levels are due to stockpiles of e-waste that are continuously exposed to the weather. With time, the outer casings of the electronic devices become weakened allowing the toxins to escape to the surrounding air, soil, and water. Prolonged exposure can lead to long-term health effects for individuals living in that area (Huo et al., 2007; Wong, 2007). There is agreement that some serious problems exist with the current management of e-waste and that change needs to take place (UNEP, 2005).

4.3 Information Technology Waste (IT-waste)

IT-waste has become a serious problem in recent years as more IT-equipment continues to become obsolete. A study conducted by The National Office of Pollution Prevention (2001) calculated that during 1999 an estimated 33,972 tonnes of IT equipment

was sent for final disposal in Canada alone. In addition, 15,592 tonnes were recycled, 24,507 tonnes were designated for reuse, and 6,128 tonnes were put into storage. Although 50% was diverted away from landfills and incinerators, this does not automatically mean that the waste was handled appropriately, especially if it was exported to developing countries (Kang and Schoeming, 2005; Nakajima and Vanderburg, 2005; UNEP, 2005). These numbers are expected to continue to grow each year as the market becomes saturated with proliferation of IT equipment (The National Office of Pollution Prevention, 2001).

4.3.1 Definition and Categorization of IT-waste

IT-waste is considered a subcategory of e-waste (Table 4.1 and Appendix A). Products identified as IT equipment include technology that uses a source of power in order to acquire information. Products that are classified as IT include any type of personal computer, monitors, printers, keyboards, CD-ROM and disk drives (Appendix B) (Nakajima, and Vanderburg, 2005).

Table 4.1 Category of products examined for this research

Product	Definition	Included	Weight
Desktop computer	Stationary computer that runs on primary source of power	Computer terminals Microcomputers Minicomputers	7.6 kg
Portable computers	Mobile computer that contains a central processor and that can run on battery or primary source of power	Laptops Notebooks Notepads Tablet PCs	2.2 kg -4.0 kg
Input peripherals	Products added to the computer externally to increase the functionality	External disk drives Optical drives Mouse Keyboard	0.1 kg- 2 kg
Storage peripherals	Products added to the computer to improve performance	Internal disk drives Optical drives	0.1 kg-1.7 kg
Monitors	Standalone video display screens that vary depending on size and display technology	Cathode Ray Tube (CRT) Liquid Crystal Display (LCD)Plasma	CRT: 13.5 kg-15.6 kg LCD and plasmas: 4.9 kg- 12.2 kg
Printers	Device that can print images and may also scan, copy, and fax	Desktop printer Desktop multi-function machines Desktop fax machine	2.7 kg- 16.5 kg

Source: OES, 2008a

4.3.2 Additional Issues Associated with IT-waste

All of the issues identified above can also be seen with IT-waste management. It is important however to examine IT-waste separately since added complications exist with accelerated rate of disposal and the complexity associated with different components (Envirosris, 2001). For example, the lifespan of a computer has steadily decreased because of

continuous technological advancements in the areas of memory, speed, new operating systems, weight, and enhanced audio/visual capability (Envirosris, 2000). In 1992, the average first life of a computer was 4.5 years. By the year 2005 it was determined to be only 2 years (Babu et al., 2007; Kang and Schoeming, 2005). Furthermore, a study by Kang and Schoeming (2005) indicated that 50% of computers discarded at a collection facility were still in working condition. This same type of rapid disposal of a workable product has also been identified with one other type of e-waste product, cell-phones (Envirosris, 2001). The continuous turnover of new IT equipment as well as increased annual sales has created an unexpected influx in the amount of IT-waste to the solid waste stream (Kang and Schoeming, 2005; Lee et al., 2007).

A study conducted in 1999 found that in Canada there was a 16% increase of 1.9 million computers purchased for residential use, over the year before. The residential sector led all other sectors for growth in Canada. This increase led the business sector (13% increase) and the educational sector (9% rise). Within all sectors of society, positive growth took place in computer acquisition (Envirosris, 2000).

The residential sector is more likely than any other sector to direct obsolete IT equipment directly into the regular municipal waste stream (Envirosris, 2001). It is difficult to accurately determine just how much IT equipment is being sent into the municipal waste stream from residences especially when IT-waste does not have to be separated from the rest of the solid waste stream in many regions in Canada (Envirosris, 2000). Since residents discard their IT-waste at different time, it is difficult to analyze the compounding effects of

independent actions. As a result, it is difficult to analyze the effects IT-waste is having (Envirosris, 2001).

Residents often decide to stockpile old IT equipment for years instead of getting rid of it once it has become obsolete. More than 70% of retired consumer electronic devices (CED) are kept in storage for an additional 3-5 years before disposed (Kang and Schoenung, 2005). Commonly cited reasons include the belief that it still has value and that it contains sensitive information (Grossman, 2006; Kang and Schoenung, 2005). The problem with storing obsolete IT equipment is it becomes even more difficult to recycle as it gets older. Product designs for IT equipment continuously change which means changes in recycling practices are also required (Kang and Schoenung, 2005). Thus, the residential sector plays a key role with respects to IT-waste that is found within the municipal waste streams (Environment Canada, 2006; Envirosris, 2001).

4.3.3 Materials Found Within IT Equipment

The mixed composition of glass, metals, and other materials components makes it complicated and costly for dismantling and recycling. Roughly one-third of IT equipment is comprised of plastic. Most of this material is used to cover the inner workings of the electronic device. The majority of this plastic, 75% is either coated, mixed with other resins or made with different flame-retardants chemicals. These added materials make it harder to recycle the plastic because it is no longer pure but rather contaminated with other material (Kang and Schoenung, 2005; Nakajima and Vanderburg, 2005). The same situation applies to glass. Glass used in a cathode ray tube (CRT) is treated with a number of substances that are required for coloring, corrosion resistance, and protection from X-rays (Kang and

Schoenung, 2005). The addition of these varied substances causes separation difficulties and other associated problems in managing IT-waste appropriately.

Not only does mixed composition create challenges, but also the specific materials found within IT equipment are a matter of concern (Table 4.2). Leaching of these materials can contaminate soil, water, and air and not only affect wildlife, but also human health. Exposure to these materials can lead to a wide range of health issues (Table 4.2) (Grossman, 2006; Schmidt, 2002). The National Office of Pollution Prevention (2001) estimated that in 1999 there were 1,356 tonnes of lead, 2.0 tonnes of cadmium, and 0.5 tonnes of mercury disposed in Canada just from PCs and monitors alone. These numbers have continued to rise each year as more IT equipment becomes obsolete (National Office of Pollution Prevention, 2001). The composition of the different IT substances and their inherent reliance on hazardous materials has created additional barriers for the sustainable management of obsolete IT-equipment.

Table 4.2 Hazardous materials found within IT-equipment

Material	Location	Health impacts	Source
Aluminum	CRT, used in printed wiring board as conductors and connectors	Skin rash, skeletal and respiratory problems, associated with Alzheimer's disease	Grossman, 2006 Schmidit, 2002
Arsenic	Printed wiring board	Allergic reactions, vomiting, abnormal heart rhythm, increase risk of cancer	Schmidit, 2002
Beryllium	Used in circuit boards as conductors and connectors	Long disease, allergic reactions, increase risk of cancer	Grossman, 2006 Five Winds International, 2001 Schmidit, 2002
Brominated flame retardants: PBB and PBDE	Plastics, printed circuit boards, components, cables	Increase risk of cancer in the digestive and lymph systems	Brenniman and Hallenbeck, 2002 Five Winds International, 2001
Cadmium	Plastics	Affects the kidneys	Babu et al., 2007 Brenniman and Hallenbeck, 2002 Five Winds International, 2001
Chromium IV	Decorative, housing of the computer	Strong allergic reactions , ulcer, liver and kidney damage, DNA damage, increase risk of cancer	Babu, et al., 2007 Brenniman and Hallenbeck, 2002 Schmidit, 2002
Gallium	Semiconductors, printed wiring board	Increase risk of cancer	Schmidit, 2002
Halogenated substances: PVC and PCB	Plastics used in cabling and computer housing	Increase risk of cancer	Brenniman and Hallenbeck, 2002 Five Winds International, 2001 Grossman, 2006
Lead	Computer monitors,	Damage to the central and	Babu et al., 2007

	CRT, metal connector	peripheral nervous system, blood system, kidneys, developmental problems	Brenniman and Hallenbeck, 2002 Five Winds International, 2001 Grossman, 2006 Schmidit, 2002
Mercury	Printed circuit boards, batteries, CRT, printed wiring	Chronic brain, kidney, lung and fetal damage, allergic reaction, increase risk of cancer,	Babu et al., 2007 Brenniman and Hallenbeck, 2002 Five Winds International, 2001 Grossman, 2006 Schmidit, 2002
Nickel	Printed wiring board, CRT	Reparatory problems, increase risk of cancer	Grossman, 2006 Schmidit, 2002
Silica	Glass, CRT, printed wiring board	Reparatory problems, increase risk of cancer	Grossman, 2006 Schmidit, 2002
Vanadium	CRT	Lung and throat irritations	Schmidit, 2002

4.4 Options for IT-waste Disposal

There are seven separate routes for IT equipment at the end of first life: Storage, export, reuse, service and refurbish, remanufacture, recycle, and final disposal (Envirosris, 2000; Jofre and Morioka, 2005). These different disposal options may be used once or several times before a product has reached its final end life (see figure 4.1). Although some strategies are more favorable than others from an environmental and economical perspective, the route selected is often dependent on whether the option is available and on the quality of IT-equipment (Jofre and Morioka, 2005). What is important is to examine each alternative in order to identify associated benefits and limitations.

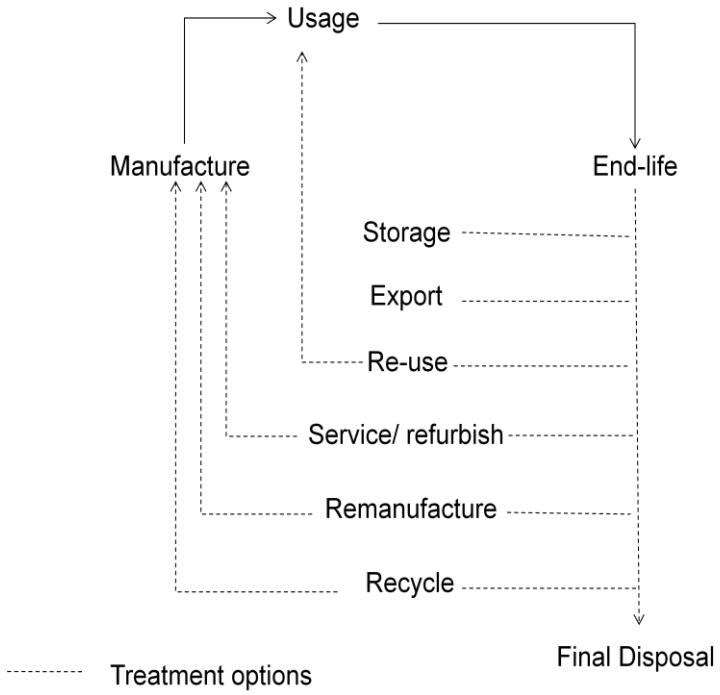

Figure 4.1 Different stages obsolete IT-waste can go through before it final end-life

4.4.1 Storage

For many individuals, keeping obsolete IT-equipment in storage is the method of choice for handling IT-waste. Their rationale is that the only incurred cost is space. Equipment is often left in the basement, closet, or storage facilities for years (Kang and Schoenung, 2005). There are a number of problems with this option. First, valuable materials are not being recovered and reused. Second the equipment continues to get older each year and become more difficult to recycle in the end. Third, there is the potential for equipment to become damaged and to release hazardous chemicals into the surrounding area (Envirosris, 2000). Storage only delays the time when IT-equipment will sooner or later have to be sent away for some type of disposal.

4.4.2 Export

For some recyclers, shipping IT overseas to developing nations is considered to be a cost-effective measure for handling waste. Fewer governmental regulations eliminate constraints. Additional costs associated with transit can be offset by lower wage offshore workers receive (in China, $1.50 per day) (UNEP, 2005). Overseas workers may not be given appropriate tools to protect themselves, and in certain circumstances there is complete disregard for the environment. Amendments to the United Nations (UN) 1995 *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* (Basel Convention, unknown) and the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations* (Environment Canada, 2009) are internationally legislated documents created to prevent developed nations, such as Canada, from exporting hazardous materials elsewhere in the world. Canadian recyclers have been able to set aside both documents for several reasons. First, the UN Basel Convention amendment to ban the export of hazardous waste from developed to developing nations has not yet been ratified by Canada or the required three-fourths of the other nations that accepted the convention, making it legally non-binding. Second, the Export and Import Regulation does not inhibit hazardous waste from being exported, but only offers recommendations as to how it can be controlled. Finally, recyclers do not consider IT-waste as garbage, but rather it is viewed as products which are being sent to developing nations to be reused, repaired or refurbished (Whitney and Webb, 2008). Exporting shifts IT-waste management to other countries. These countries often do not have the proper resources to recycle waste safely and appropriately.

4.4.3 Reuse

The saying “one man’s trash is another man’s treasure” directly applies to reuse. IT-equipment that might be considered obsolete to some may be useful to another. Oftentimes this equipment is still fully functional and can continue to have a long performance life. The reuse option extends the life of IT-equipment by passing it on to another individual who still sees value in it (Jofre and Morioka, 2005). Typically there are two reuse options: either resale or donation to charity (Envirosris, 2000). Although the reuse option increases the life-span of a product, some problems have been identified. Used IT-equipment that is completely outdated may be better disposed of. For example, energy required to run a computer has greatly been reduced over the years due to continuous technological advancements (Intel, 2002). More resources are required to power older equipment which leads to other problems such as increased resource depletion of fossil fuels. Antiquated equipment is sent to developing countries as charitable donations normally will be used minimally before reaching its final end-life. This equipment is then added to the already growing waste stream in third world countries where there are limited waste standard practices in place (UNEP, 2005).

4.4.4 Service or Refurbish

IT-equipment that is still valuable but has not been maintained or has become defective is not necessarily worthless. A more appropriate option may be to identify and repair problems in order to extend the life of the product (Jofre and Morioka, 2005). Although some additional resource inputs may be required they can be minimal compared to what would be required to produce the same product again. All new IT-equipment requires a

large assortment of different raw materials. Numerous resources (capital, energy, water, and human) are used, from the mining and smelting phases for metals, through to resource inputs in the manufacturing process. These actions have environmental impacts. Creation of waste and pollution, use of non-renewable resources, damaged topography, and social conflict are just some of the many negative impacts that have been identified as associated with the procurement of raw materials for IT production (Grossman, 2006). Servicing a product instead of discarding it helps to extend the product's life so that the environmental, economical, and social impacts from its manufacturing can be more fully offset.

4.4.5 Remanufacture

IT-equipment that cannot be repaired may still have workable component parts which might be recovered and then later reused in other IT-equipment. Remanufacturing allows workable parts such as hard-drives, DVD-drives, and keyboards to continue to be used by being paired with other new or used IT-equipment. This option helps to prevent the useable parts from being sent on less favorable routes such as recycling or for final disposal (Jofre and Morioka, 2005).

4.4.6 Recycle

In the waste hierarchy, recycling is a more favorable option for handling IT-waste than final disposal. Recycling allows for valuable materials (steel, copper, lead, zinc, gold, platinum, and silver) to be recovered and reprocessed into new goods without having to use virgin materials (Jofre and Morioka, 2005). However, recycling can be a complex procedure based on the number of different approaches, processes, and actors that are involved in its execution. Primary recycling, identifying and separating re-usable and serviceable equipment

from obsolete IT products, is the first line of recovery. Equipment that cannot be salvaged is generally dismantled manually— individuals physically disassemble and remove all hazardous components (Bilitewski et al., 1997). Once hazardous components are removed, all other component parts go through the material recovery facility which separates sorts and sells materials to secondary recyclers who in turn process the metals, plastics and glass found within IT-equipment (Envirosris, 2000). Highly automated methods such as mechanical, chemical, and thermal approaches may be used in recycling processes.

The mechanical approach further breaks down component IT parts into more specialized categories through the utilization of various separation technology methods. Machines can be programmed to sort by size reduction and composition (magnetic versus nonmagnetic) different materials which then may be shredded and ground for even further separation. The thermal approach involves the use of extreme heat to break down metals and plastics. Byproducts created from the thermal process include: dust, soot and heavy hydrocarbons. These materials have the potential to be used as energy sources if specific substances are added to the mix. Chemical recycling is a complicated procedure due to the different materials that exist within IT-equipment. The main goal of this approach is to recover precious metals from printed circuit boards and other components. Various solutions are used to extract metals. The solutions used (acids, bases, or salts), temperature, and leaching time are all dependent on the chemical and physical composition of the structure being recycled (Bilitewski et al., 1997; Kang and Schoenung, 2005). With all of these different recycling processes, materials otherwise considered worthless are being diverted away from the landfill and incinerator.

Recycling with any of these processes is not perfect. There are always problems with waste generated from recycling processes and the potential for hazardous substances to be released. Plastics that contain bromine or chlorine compounds can create dioxins and furans when incinerated. Hazardous materials such as mercury and lead can be released as dust and fume particles, when cathode ray tubes (CRT) and printed circuit are crushed, shredded, or heated. Precautionary measures such as proper handling and controlled pre-treatment of IT-waste are important in order to help alleviate some of these problems (Envirosris, 2000).

4.4.7 Final Disposal

There are two different types of final disposal of IT-equipment, either incineration or landfill. Both of these options are the least preferred choice to manage IT-waste because hazardous materials are unable to be collected and separated.

The incineration option collects and burns waste. Some incineration facilities have the capability to capture heat created from the furnaces and to recover it as energy. However, incinerating IT-equipment increases the risk of releasing toxins and hazardous materials into air. For example, plastics contain a number of additives including polybrominated diphenyl ethers (PBDEs) which is a type of flame retardant. It utilizes a halogenated compound to suck out the surrounding air needed to sustain a fire. Although it does not prevent product combustion all together, it does significantly delay the process (Grossman, 2006). Incineration can release hazardous compounds such as polybrominated dibenzodioxins (PBDDs) and polybrominated dibenzofurans (PBDFs) into the air which can lead to bioaccumulation in humans and wildlife populations. Problems also exist with the residue deposit (slag, fly ash, flue gas, and filter cakes) from the incineration process. High

concentrations of metals are found in these leftover materials that are then sent to landfills where they have the potential to leach into the surrounding area (Brenniman and Hallenbeck, 2002; Five Winds International, 2001).

According to the National Safety Council, in the United States alone an estimated 63 million or 85% of computers discarded in 2002 were sent to landfills (Grossman, 2006). This number means that a large portion of heavy metals were not recovered and remanufactured, but rather took valuable landfill space. Furthermore, the deposits from incineration residue and IT-waste have high levels of heavy metals, halogenated substances, and hazardous substances that can negatively impact the environment. Even the best landfills are not perfect and leaching is a major concern (Grossman, 2006). IT-waste heightens the seriousness of the situation because it adds a variety of dangerous components to the mix without having any real controls in place to manage the overall complexity associated with it (Brenniman and Hallenbeck, 2002; Five Winds International, 2001).

In North America, IT-waste management is in its infancy stage, especially when compared to the initiatives taking place in Europe. Most IT-waste management operations in Canada are unregulated and voluntary. Each municipality decides how to handle IT-waste because there are no national standards in place and because municipalities are responsible for financing all waste programs within their region (Whitney and Webb, 2008). Consequently, some municipalities decide to implement bans on IT-waste while others do not. Problems can arise when neighboring municipalities take different approaches, particularly if there are fees associated with IT disposal. Potential problems may include illegal dumping of IT-waste, extended storage, garbage contamination based on attempts to

avoid fees, or disposing of IT-waste in other municipalities (Nixon and Saphores, 2007; Saphores, 2006). All of these problems hinder the overall success of programs.

In 2004 it was estimated that 19,290 tonnes of IT-waste was discarded in Ontario alone (WDO, 2005). Most of the waste was older PCs and CRT monitors purchased 6 to 8 years previously. Because of the limited availability for IT recycling at the residential level, only 579 tonnes were collected and processed, leaving 18,711 tonnes to be sent to landfills or incinerators. The purchase of IT products continues to increase each year as the lifespan of IT equipment decreases (WDO, 2005). Consequently, the number of IT products becoming obsolete each year is rising, leading to greater stress on the waste stream.

4.4.8 Waste Management Responsibility in Ontario

Municipalities take primary responsibility for the management of solid waste. Council normally decides what type of collection program (drop-off, permanent collection depot, curbside collection, etc.) will be established, how waste management will be funded (through taxes, pay as you go, permits, etc.), how often it will be collected (weekly or bi-weekly) and if any waste bans are in effect. Although the municipality has the freedom to design e-waste management programs, the province has tried to help. In 2004 Ontario's Ministry of the Environment passed Regulation 393/04 to develop a provincial e-waste program (Jofre and Morioka, 2005; Whitney and Webb, 2008).

4.4.9 Current Management Programs for IT-waste

As of 2006, there were 60 municipal IT-waste programs implemented in the province of Ontario. The combined efforts of these programs led to an estimated 572 tonnes of IT-waste diverted from final disposal (OES, 2008c). Each IT collection program is tailored to fit

municipal needs. Variations in collection method (drop-off, curbside collection, permanent collection deposit), location site (landfill, transfer station, recycling center, industrial zone), operation times (year round, seasonal, or special events), cost (fees vs. no fees), collection system (mixed or separated) and disposal options (re-use, refurbish, recycle, or export) affect the design, implementation and success of programs (CSR et al, 2005; OES, 2008c). While 60 municipalities in the province have an IT-waste diversion program, 385 do not.

For individuals who live in a municipality that does not provide IT-waste collection, there are a number of different options. First, residents could send the product back to its manufacturer. Several different IT manufacturers have taken on corporate initiatives to recycle their end of life IT equipment. However, there are strict guidelines to follow when it comes to the particular brands and products available for the service, and the cost associated with it (see table 4.3). Second, the waste may be taken to special collection events hosted by retailers such as Staples, Best Buy, and Future Shop (OES, 2008c). Third, residents might find a material recovery facility or recycler who is willing to take obsolete IT equipment. With this option, individuals are often expected to pay some sort of handling fee for the service. Finally, the new OES program provides residents the opportunity to send their IT-waste for recycling or reuse for free (OES, 2008c). Even though there are different programs available to dispose of unwanted IT equipment, there are no universal rules explicitly to prevent IT-waste from entering landfills or incinerators. All of these options require individual residents to spend the time, effort and in most cases money to see to it that their IT-waste is handled in a more appropriate manner. Only a small numbers of municipalities have enacted bans to force residents to divert this waste away from the regular waste stream.

Table 4.3 Different Canadian manufacturing programs for handling IT-waste

Company	Products	Disposal	Cost	Source
Apple	All computer types and monitors	Recycle	$30	http://www.apple.com/environment/
Dell	All computer types	Recover, recycle, donate,	Free	http://www1.ca.dell.com/content/topics/segtopic.aspx/dell_recycling
HP	Any brand of Computer equipment	Recovery and recycle	Cost depending on the product	http://www.hp.com/hpinfo/globalcitizenship/environment/recycle/
IBM	Any brand of computer equipment	Recycled	$49.95	http://www.ibm.com/ibm/environment/products/recycling.shtml
Lexmark	Printers	Recycled	Free	http://www.lexmark.com/uncomplicate/sequentialem/home/0,7070,204812589_307451399_307570842_en,00.html
Sony	Any type of notebook and laptop computer	Recycle and refurbish	Trade in for credit towards a New purchase	http://www.sonystyle.ca/commerce/servlet/StaticView?storeId=10001&catalogId=10001&contentpage=../html/trade_in/faq.html
Toshiba	Any type of notebook computer, LCD monitor, or pocket PC	Recycle	Free	http://www.toshiba.ca/web/link?id=2200

4.4.10 Facilities for Handling IT-waste

Currently there are three categories of facilities that handle IT-waste. Each of these facilities provides a service that is different. Refurbishing centers extend the life of a product

by reintroducing it back into public use. Processing facilities extract valuable materials found in products in order for them to be reprocessed into newly formulated products. Landfills and incinerator plants provide final disposal.

There are several different routes by which obsolete IT equipment finds its way to these facilities. They are dependent on whether the equipment is still useable or not. If products are in working order or just need some minor repairs, they can be sent to one of two places, small independent reuse stores or national refurbishing centers. Reuse stores are found throughout the province where used IT equipment is repaired and then reformatted before it is resold at a reduced rate to the public. National refurbishing centers such as Computers for Schools and ReBOOT are nonprofit organizations that gather obsolete IT equipment from all over Canada. They collect and fix used equipment before redistributing it back to the public – either schools or low income recipients. The act of reusing and refurbishing, either at the small or large scale, helps to extend the life of the equipment without creating any further harm to the environment (CSR et al, 2005).

Processing companies also handle IT-waste. As of 2005, there were 17 processors located throughout Ontario working with a variety of WEEE products, including IT equipment. At some of these processing facilities, workers are required to physically check and separate equipment, depending on its functionality. The objective is to resell or to donate workable products to other companies so they can be refurbished and reused once again. At other facilities, working and nonworking products are mixed together for recycling. An Ontario study found that the majority of material sent for processing was either recycled or reused, about 5% was landfilled or 30% was sent for incineration (CSR et al, 2005).

Materials recovered from recycling are oftentimes sent back to their respective material market where they are used to create new products. The task of the processors is to prevent further extraction of virgin material by supplying the material market with useable materials.

With the landfill and incinerator option, IT products are mixed with other forms of waste complicates the situation and creates three main problems. First, it becomes extremely difficult to extract these products from the regular waste stream. Second, they usually become damaged as little care is given when it comes to their handling. Broken equipment can lead to a whole host of other problems including leaching of hazardous materials. Finally, valuable minerals are lost because the materials are unable to be processed (Brenniman and Hallenbeck, 2002; Five Winds International, 2001). With all these problems, landfilling and incineration is still considered an acceptable option by many because of the ease and accessibility associated with it.

4.4.11 Future Direction of IT-waste Management

Regulation 393/04 under the Waste Diversion Act (WDA) was filed by the provincial Minister of the Environment, in December of 2004 in order to develop a waste diversion program for WEEE. The WDA is a policy initiative designed to encourage the reduction, reuse, and recycling of any type of waste identified under the Act. Waste Diversion Ontario (WDO) oversees the development, establishment and implementation of waste diversion programs for materials under the Act, including WEEE (OES, 2008c; WDO, 2007a; Whitney and Webb, 2008). The Minster of the Environment has already implemented a number of diversion programs for other problematic waste including blue box waste, tires, and household hazardous waste. Under the Act, brand owners are held responsible for their

products and therefore are required to pay the cost for the development and running of a diversion program (WDO, 2007a). In September 20, 2007 the electronic industry and retail sector established Ontario Electronic Stewardship (OES) to help with the development of a provincially run recycle and reuse e-waste program. OES is an industry-funded organization that works in conjunction with the WDO to create and operate the WEEE program plan. Its goal was to meet the Minister's requirements: developing collection and diversion targets; programs that are effective and convenient; increase participation through education and outreach campaigns; tracking and monitoring e-waste to improve diversion programs in the future; and standards for vendor handling of obsolete e-waste (Whitney and Webb, 2008). The Minister requested a phase- in approach for the implementation of a WEEE program, with IT-waste being included in the first phase. Although this e-waste program will be available free of change to the public, there are no regulations that clearly ban e-waste from entrance into the municipal waste streams in Ontario. Rather this program offers a service that residents can decide whether or not to use (OES, 2008c). As part of this research a review of this OES program (Chapter 6) was undertaken to determine the effectiveness of the program and what impact it will have on IT-waste management. Analysis of the program came from the sustainable IWM criteria developed through the literature review and the 5 country European case analysis. The criteria can be found in chapter 5 section 5.4.

4.5 Conclusion

There are no rules forcing residents to use one disposal option over another. Residents have the ultimate choice of which collector they will chose to manage their EOL IT-waste. Decisions maybe based on convenience, cost, and or environmental and social

conscientiousness. Whatever collector a resident chooses to use will influence which route of disposal the product will go down. Many options exist for EOL IT-waste— reuse, repair (refurbish remanufacture) recycle and final disposal. The appropriate management choice depends on the availability of options for a particular region as well as the quality of the equipment. For example, 8 year old equipment sent for reuse may have more adverse environmental impacts because of the amount of energy required to power it than if it had been recycled. For each choice, there are both benefits and limitations which must be considered. Eventually after so many times going through the cycle and getting downgraded will there be no other option except final disposal. EOL IT-waste management takes a reactionary approach to the problem. It extends the life of waste but does not eliminate waste. Figure 4.2 illustrates the complex nature of EOL management of IT-waste in Ontario and the many different routes and stakeholders involved.

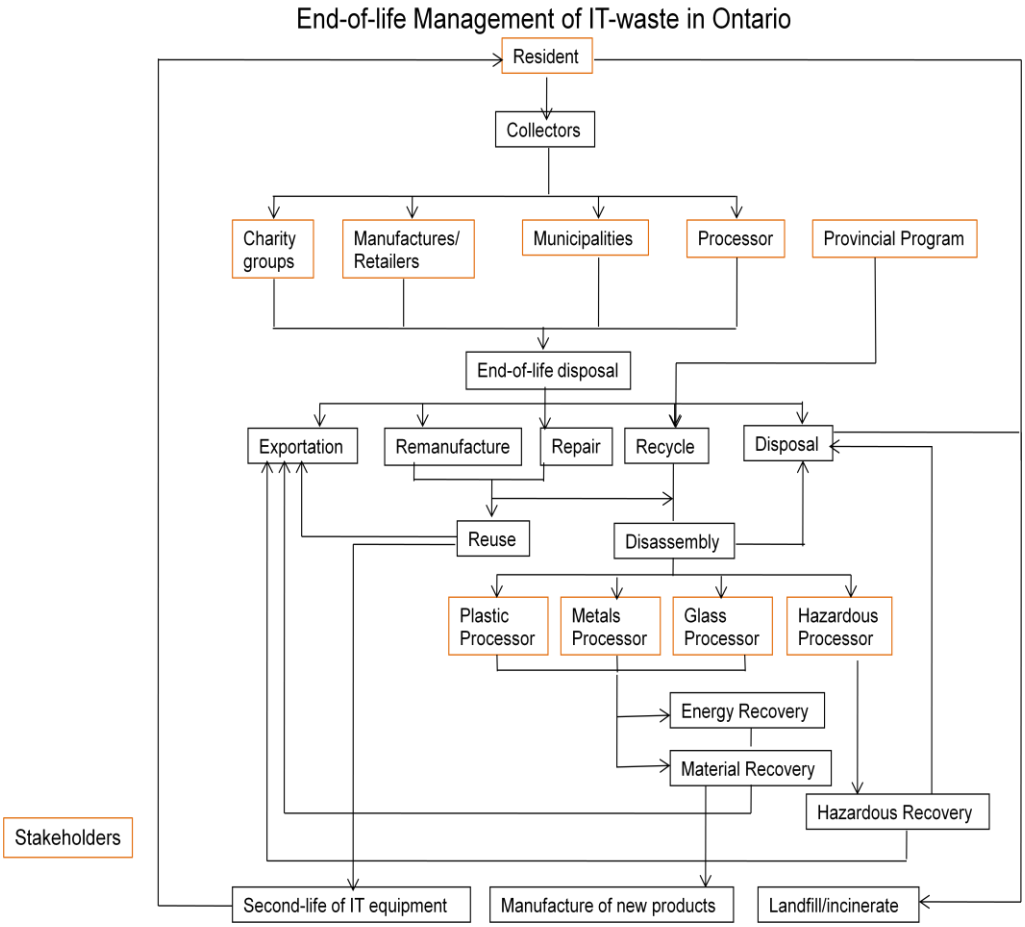

Figure 4.2 A chart illustrating the different routes IT-waste can go for management (Modified from Envirosris, 2000; He et al., 2006 Jofre and Morioka, 2005; Mayers, et al., 2005)

Chapter 5: European 5 Case Analysis and Criteria for Sustainable IT-waste Management

5.1 Background

One aspect of this research has been to examine what has already been done and to use lessons learned to inform the design and development of recommendations for information technology (IT)-waste programs elsewhere. Five European countries' waste electronic and electrical equipment (WEEE) programs were chosen based on several different factors including human development index, gross domestic product (GDP), and a system of government comparable to that of Canada and Ontario. The human development index was selected because it identifies the wellbeing of a country. It measures the life expectancy, literacy, educational attainment and GDP. Being able to use IT equipment effectively requires time, education, and money which is more available to countries ranked higher on the human development index (Desai et al., 2002). GDP was examined independently because it measures wealth within a country. Individuals need some sort of income in order to be able to purchase IT equipment (Desai et al., 2002). Identifying countries with the same system of government was also important for how decisions are made. All e-waste programs studied came from countries required by law to have an e-waste management program under the European WEEE Directive (see table 5.1). All five programs were examined for the following characteristics: regulation policy, collection totals, financial support for running the program, responsibility and management, drop-off convenience, reporting and monitoring of products, and stakeholder compliancy and education.

Table 5.1 Countries characteristic of human development, GDP, and system of government

County	**Human development index**[1]	**GDP (US$)**[1]	**System of government**
Canada	.961	33,375	Parliamentary
Belgium	.948	33,243	Parliamentary
Denmark	.949	33,973	Parliamentary
Netherlands	.953	32,684	Parliamentary
Norway	.968	41,420	Parliamentary
Sweden	.956	32,153	Parliamentary
Switzerland	.955	35,633	Parliamentary

[1]all information came from the human development reports (2008).

5.2 European WEEE Program

5.2.1 Overview

The European Union (EU) WEEE Directive (Directive 2002/96/EC) has received the greatest amount of attention in the literature in comparison to other e-waste initiatives (Whitney and Webb, 2008). The Directive is an EU policy that regulates the handling and the disposal of WEEE for all member states of the EU (European Parliament, 2001). Although the Directive provides general guidelines when it comes to producer responsibility, waste management standards, product labeling, and targets for recovery and reuse or recycling, each country determines how to meet the overall objectives (see table 5.2 and 5.3) (European Commission, 2006). Legislation may vary between countries, but the end goals remain the same for all: first to promote prevention and second, to accomplish reduction, recovery and recycling of e-waste products. The WEEE Directive promotes awareness and provides recommendations for managing electronic waste (e-waste). It seeks to move responsibility away from the consumer to the producer to ensure e-waste is treated in the most environmentally responsible manner possible (Envirosris, 2000; Hischier, 2005; European Parliament, 2003; Jofre and Morioka, 2005; Nakajima and Vanderburg, 2005).

Table 5.2 WEEE Directive general guidelines for member states

Area	General guidelines
Producer responsibility	-Financially responsible for taking back products at end of their life -finance the treatment of products
Waste management standards	-Separate and collected WEEE from regular waste stream -4 kg/capita/year of WEEE -Records to be kept regarding amount of material entering and leaving treatment, recycling, and recovery facilities
Labeling and information	-New products must identify who the producer is -Provide consumer with information regarding collection systems available -Explain the environmental and health effects associated with the product

Source: European Commission, 2006

Table 5.3 Recovery and recycling rates for different WEEE products outlined in the Directive

Product	Recovery	Recycle/reuse
Large household appliances	80%	75%
Small household appliances	70%	50%
Information and telecoms	75%	65%
Consumer equipment	75%	65%
Lighting	70%	50%
Tools	70%	50%
Toys, leisure, sports	70%	50%
Monitoring instruments	70%	50%
Dispensers	80%	75%

Source: European Commission, 2006

The movement to implementation was accomplished in a relatively short period of time. The WEEE Directive was passed on February 13, 2003, by both the European Parliament and the Council of the EU. By August of 2004, all member states were required to have a take-back program up and running. As of December 31, 2006, each state was expected to comply with the 4 kg/capita/year collection target set by the Directive (Hischier, 2005; Nakajima and Vanderburg, 2005). Plans for the future include higher collection targets set and met by member states of the EU. However, the success of the WEEE Directive is only as good as the stakeholders involved.

State governments, consumers, and manufacturers have all been identified as playing key roles with regards to the implementation of the WEEE Directive. Each stakeholder not only has specific obligations to its country's program but also general responsibilities to the Directive. For instance, national governments are required to develop and to maintain a list of registered electronic producers. They are also responsible for submitting a written report to the Council of the EU every 3 years with regards to their country's WEEE program performance. Finally, each government is obligated to develop and impose penalties for non-compliance with the Directive. Consumers are required to return obsolete WEEE to a designated collection site for proper handling (Nakajima and Vanderburg, 2005). At this point it becomes the job of all manufacturers selling products in the EU to finance the collection, treatment, recovery, and disposal of WEEE products. Much of the responsibility has been placed on these stakeholders because the European Council environmental policy is based on the precautionary, polluter pay, and prevention principles for decision making (Envirosris, 2000). This arrangement provides incentives for manufacturers to redesign products to be more environmentally appropriate so that there will be less future economic strain placed on them (Kibert, 2004).

Financial consequences are not the only factors motivating manufacturers to redesign products with the environment in mind. Another reason was the enactment of Restriction of Hazardous Substances (RoHS) Directive by the EU (Directive 2002/95/EC). This Directive prohibits the inclusion of hazardous materials from inclusion in electrical and electronic equipment (EEE). Lead, cadmium, mercury, hexavalent chromium, and brominated flame retardants (PPB and PBDE) have all been identified as substances forbidden from being used

in the production of new EEE. Consequently, manufacturers are now required to redesign their products without these elements if they want to sell them on the European market. The WEEE and RoHS Directives complement one another. They force change through product responsibility and design. RoHS Directive takes a preventative approach by trying to eliminate hazardous waste at the beginning stages of product production while the WEEE Directive tries to prevent problems with handling and disposal later on down the road (Oh and Thompson, 2006).

5.2.2 General Criticisms of the WEEE Directive

There are some who believe the WEEE Directive does not fully promote e-waste recycling. First, the 4 kg/capita/year places a 'one size fits all' target on all countries. On average 16 kg of WEEE is generated per capita in the EU, yet only 4 kg/capita/year are required to be collected. This number does not provide any incentives for improvement by countries, particularly those in Western Europe that have already met the target. Conversely, the target for some new member states it may be too difficult to achieve at this point in time (United Nations University, 2008). The second issue deals with standards for dumping or allowing e-waste to be "recycled" in developing countries. Standard dumping does not count towards a country's mandatory recovery and reuse or recycling targets, unless the exporter can prove the processes are equivalent to the standards outlined in the Directive. The Directive does not force 100% recycling and therefore additional e-waste can still be sent to landfills or developing countries (Ahlumalia and Nema, 2007; Robinson, 2003; Wong, 2007). One further issue is that each country drafts its own national policy and accompanying legislation. Consequently, variations are to be seen between national programs

which has led to increased cost and confusion (Nixon and Saphores, 2007). Below, this research summarizes the results of an evaluation of some programs and legislation that will help to highlight both the benefits and limitations that are inherent in different member state's efforts to implement the Directive.

5.3 European Countries E-waste Programs

Most of the information from this section comes from one report that extensively examined different WEEE programs. The report, *Study into European WEEE Schedule* was prepared for the United Kingdom Department of Trade and Industry in 2003. A new report conducted for the European Union will be released sometime later this year (2009) and will provide new data with respects to progress (Savage et al., 2006).

5.3.1 Belgium

Belgium currently has one of the longest running take-back programs in the EU due in large part to its national waste act. The waste act allows regional environmental agencies to require electronic producers to develop a take-back program to remove certain types of WEEE from the waste stream. In 1998, the Flemish region implemented the first regulation in Belgium to force manufacturers, importers, distributors, and retailers to take back free of charge certain types of white (refrigerators, stoves, oven) and brown goods (audio-video), including IT-waste (Envirosris, 2000). By July 2001 a national program was put in place to collect and recycle all types of WEEE (Recupel, 2007).

Producers that do not wish to take responsibility for managing their e-waste can always join Recupel. Recupel manages the collection, transportation, treatment, and monitoring of WEEE in Belgium. It is a non-profit program run by representatives from the

electronic industry. Producers, sellers, and exporters of electronic and electrical products can pay an annual fee to be members in one of five different sectors (Recupel A/V— consumer electronic equipment; Recupel SDA— small household appliances; Recupel ICT- IT — office and telecommunication equipment; B/W-Recupel— household appliances; Recupel ET and garden— electrical and garden tools) depending on the products they deal with (Future Energy Solutions, 2003). Members compensate for these annual fees by imposed fixed visible fees on the purchase of their electronic and electrical equipment (EEE) (Future Energy Solutions, 2003). Being a member ensures that the company is complying with Belgium's legislative requirements for WEEE and that their products are being managed appropriately (Nakajima, and Vanderburg, 2005). It also allows consumers to drop-off all types of e-waste without any charge.

Since 2006 there have been over 3,441 drop-off centers established in Belgium where consumers can take their unwanted WEEE. Drop-off centers include regional collection stations, retailers, container parks, and used good centers (Recupel, 2006). When products come in they are sorted and separated into one of four different categories (TV/M— TV and computer screens; KV— cooling and freezing equipment; GW— large white goods; OVE— small white and brown goods and information communication technology equipment) (Recupel, 2006). Once enough waste has been collected at a drop-off center, trucks transport the waste to one of five different recycling facilities. Each facility was selected based on its environmental and efficiency performance. To ensure consistent performance, several measures have been put in place. Independent auditors annually audit each facility to ensure environmental and economic performance standards are being met. Recupel must submit an

annual report to the regional authority identifying the type and amount of products collected, where they came from, and how they were treated. Both of these measures try to ensure that products are being accounted for and managed most appropriately (Future Energy Solutions, 2003).

The amount of WEEE collected in Belgium has grown rapidly. In 2002, roughly 3.6 kg/capita/year of WEEE was collected, which unfortunately fell below the 4 kg/capita/ year target set by the WEEE Directive. By 2006, 7.22 kg/ capita/year of WEEE was collected (Recupel, 2006). In 4 years Recupel not only doubled its collection numbers but met all the recycling targets for product and material outlined in Belgium's environmental policy (see table 5.4).

Table 5.4 Comparison of performance between 2002 and 2006 of recycling rates

Product	Actual 2002*	Actual 2006**	Legal requirements
Large Appliances	82%	85%	80%
Cooling/Freezing	74%	91%	70%
Monitors	86%	87%	70%
Other appliances	79%	84%	70%
Materials			
Ferrous metals	99%	100%	95%
Non-ferrous metals	95%	98%	95%
Synthetic materials	41%	95%	20%
Others		54%	

* data obtained from Future Energy Solutions (2003)
** data obtained from Recupel (2006)

Recupel's job is not just about managing the collection, transportation, treatment, and monitoring of WEEE but also about promoting the importance of proper disposal. In 2002, 4% of Recupel's total budget was directed towards educational tools and research studies. Internet sites, pamphlets, national informational campaigns, recycling films, and school sponsored educational sessions have all been used to promote awareness. A study conducted by Recupel found that these educational campaigns created greater awareness and support for Recupel. Education and awareness help explain the increase in WEEE collection between 2002 and 2006. Another explanation could be that over 1,000 new drop-off centers were created to allow for easier accessibility to recycle WEEE (Recupel, 2006). Whatever the underlying reasons, Belgium has been able to meet the requirements outlined in the WEEE Directive and surpass them as they continue to enhance performance each year.

5.3.2 Netherlands

The Dutch national program for WEEE management also known as the WEEE Management Regulation came into force on August 13, 2004. It is a nationwide program

that requires any producers, importers, or organization representing companies wanting to sell their EEE in Holland, to register the amount of products they place on the market. Not only are these stakeholders required to register, but they also need to provide an outline of what actions will be taken to fulfill their recycling requirements. It is the responsibility of the Ministry for Housing, Spatial Planning and the Environment to oversee the monitoring and enforcement of these regulations. If producers fail to comply with any of the regulations, the Environmental Management Act and the Economic Offences Act allows penalties to be handed down (Industry News, 2006). Penalties include fines (25,000 to 100,000 guilders), imprisonment (up to 2 years), closure of business (up to 1 year), and compensation for damages (Sino-Swiss E-waste initiative, 2009).

Producers and importers have two choices for complying with the national WEEE Management Regulations. They can manage their own WEEE or become a member of either Stichting Nederlandse Verwijdering Metalektro Producten (NVMP) or ICT Milieu depending on the equipment they produce. If producers and importers choose to manage their waste independently, they must ensure that residential equipment collected at municipalities and distributor centers is being transported and treated in the most appropriate manner (Industry News, 2006). Two take-back programs were developed to separate white and brown goods (NVMP) from information communication technology (ICT Milieu). Although both programs have the same goal to collect and manage WEEE for their clients, they operate somewhat differently (Future Energy Solutions, 2003). ICT Milieu will be the only program examined since it manages IT-waste.

ICT uses a two-tier system for collecting from the residential and commercial sector. Where the equipment is coming from (residential vs. commercial) influences where it can be dropped off for disposal. Residents can send their equipment to municipal collection sites and regional collection and sorting depots or can trade in old products when purchasing new products. With the municipal and retail collection option, costs for transporting the waste to regional depots centers are not fully reimbursed by ICT Milieu, which means municipalities and retailers incur some of the cost. The commercial sector too has a number of different choices for disposal depending on what is best for the business. Businesses can either pass their equipment to a third party, trade in their old products for new ones, call manufacturers of the obsolete equipment to take back their products (although manufacturers not legally obligated to do so), or they can dispose through an industrial waste collector (Future Energy Solutions, 2003). With most of these options the company is required to pay a fee for collection. Once ICT waste has been collected it is transported to an approved processing plant which treats the discarded equipment.

The financial structure for processing obsolete ICT equipment has changed considerably since 2003 from a fixed annual fee plus charges per kilogram of equipment taken back to a new system based on a current market shared approach (Future Energy Solutions, 2003; Nakajima, and Vanderburg, 2005). The change was due to high levels of orphan (products of brand owners, first importers or assemblers who are no longer in business) and free ride (producers and importers who do not take physical or financial responsibility with EOL management) products being collected. The current system makes members pay fixed annual fees in conjunction with a charge that is dependent on the total

percentage of weight per category of equipment put on the market each month. This ensures that in the future products will be taken care of even if the manufacturer no longer exists. Because there is no visible fee, companies can either absorb the cost themselves or pass it on to the retailers who can add a hidden fee onto the sales price (Future Energy Solutions, 2003).

Roughly 9 million kg of ICT waste were collected and treated in 2002. However, the accuracy of these numbers is questionable because there is no formal auditing. The system relies upon self reporting by recyclers and transporters. Furthermore, because there are no recycling targets outlined in the Dutch legislation for collection and recycling, weak and varied interpretations of what constitutes recycling in the industry have resulted. Other criticism of the ICT Milieu involves lack of public awareness. Not only are there no visible fees on products to influence consumer behaviors, but almost no funding is directed towards public education. Consequently, all these factors led to only.58 kg/ capita/year in the amount of ICT collected and treated in the Netherlands, during 2002 (Future Energy Solutions, 2003).

5.3.3 Norway

On March 16, 1998 Norway's Ministry of the Environment enacted legislation entitled "Regulations Regarding Scrapped Electrical and Electronic Products" (El-Retur, 2008). The regulations stated:

- Distributors of electronic equipment are required to collect consumers e-waste free of charge
- Municipalities must provide space for consumer to drop-off e-waste free of charge
- Municipality, distributors, and producers/importers must keep e-waste disposal records

- Producers and importers are responsible for the cost and collection of e-waste from distributors and municipalities collection points
- Producers and importers are responsible for receiving e-waste free of charge from businesses
- Producers and importers must ensure that all hazardous e-waste materials are sorted and disposed of in an approved treatment facility
- Producers and importers must ensure all waste that can be recycled is

The El-Retur program was established on July 1, 1999 to comply with Norway's national legislation. It is a non-profit organization that collects, transports, and treats WEEE from any producer or importer who wishes to be a member. El-Retur is separated into two different trade organizations, Elekronikkretur AS and Hvitevaretur AS. Elekronikkretur AS is responsible for managing brown goods (audio-video) electrical and electronic games, medical equipment, office machinery, and telecommunications equipment under one of its three different organizations (EE-bransjen, IKT-Norge, and Abelia). Hvitevaretur AS is in charge of residential and industrial white goods, microwaves, and oil-filled heaters (Future Energy Solutions, 2003). Each organization decides how to run and finance its respective program.

El-Retur is used by both the residential and industrial sector for all of Norway. Residents can bring their WEEE free of charge to retailers without having to purchase a new product, or take it to a municipal collection point. As of 2006, there were 2,500 active collection points (El-Retur, 2006). Industries can go to retailers who will trade new products for old or they can send e-waste to municipalities which may charge a fee for collection. El-Retur uses six different transportation companies and five treatment organizations which have a total of twelve facilities to treat all incoming e-waste. While similar collection and

transportation approaches are used in each organization, there are differences in the financial methods employed (see table 5.7) (Future Energy Solutions, 2003).

Table 5.5 Different financial models used to manage WEEE

Organization	Product	Financial method
EE-bransjen	Brown goods	Company is charged based on the number of goods sold in Norwegian market
IKT-Norge	IT products Electronic/electrical games Office machinery	Importers and manufactures are invoice the actual recycling cost based on category market share
Abelia	Medical equipment Electronics Telecommunications	Importers and manufactures are invoiced the actual recycling cost based on category market share
NEL	white goods microwaves oil-filled heaters	Pay a fixed fee for being a member Companies can impose the fee onto their consumers in the form of a visible fee

Source: Future Energy Solutions, 2003

The Norwegian legislation requires that El-Route reports to the State Pollution Control Authority each year the production and import rates of EEE put on the Norwegian market and the quantity and brands of waste collected and treated on behalf of its producers and importers. The findings from the 2002 report shows that over 35,561 tonnes of WEEE were collected which amounts to an average of more than 8 kg/capita/year diverted from landfills. Each year the collection rate has continued to increase and by 2006, 69,373 tonnes or 14.7 kg/capita/year of WEEE were collected (El-Route, 2006; Future Energy Solutions, 2003). While El-Retur has one of the best collection rates in Europe there is still a major problem, free riders (see glossary) (El-Route, 2006). El-Retur clientele represents only 20% of all producers and importers in Norway, but 70% of electronic and IT-equipment and 80-90% of white goods sold on the market. However, thousands of small independent

companies are not represented because of the relatively high cost to join. Because of the large number of small companies operating, it is hard to police and enforce compliance of product recycling for these companies. El-Retur is trying to change this by working with the government to create a partnership so all WEEE can be treated appropriately in the future (Future Energy Solutions, 2003).

5.3.4 Sweden

The Swedish government ordinance SFS 2000: 208 was ratified on January 1, 2001. The main points included under the order were:

- Producers are obliged to setup free take-back programs with the purchase of any new products
- Producers are required to monitor the treatment of collected WEEE
- Regional authorizes are obligated to collect and treat residential WEEE
- Commercial sector is responsible for the preliminary treatment of their own WEEE

The Swedish legislation is somewhat different from the other programs found in Europe. Producers and importers are not held entirely responsible for the cost of the WEEE program rather it is divided between municipalities and producers and importers. Residents can return their unwanted WEEE to a municipal collection sites free of charge. However, the municipalities have to pay for the collection and half the cost to disseminate educational information. Producers and importers are required to pay for transporting and recycling, as well as the other half required to distribute information. In order to pay for the municipal service, residents have to pay approximately 150 dollars per year (Nakajima and Vanderburg, 2005). Furthermore, companies with WEEE that do not purchase new equipment are responsible for covering their own costs for collection (Future Energy Solutions, 2003).

El-Kretsen was established on July 1, 2001 by producers and importers. This organization was created to help producers and importers fulfill responsibilities set out in the ordnance. El-Kretsen is a national take-back program that is run by 21 trade organizations in the EEE business. There are over 500 members which cover roughly 90% of electronic and electrical products sold on the Swedish market (Future Energy Solutions, 2003). El-Kresten is responsible for the collection (old products replaced by new products), sorting, treatment, and recycling of all WEEE.

At the point of collection, WEEE is separated into one of three different categories: electronics, large white goods, and light sources. Products are then transported to one of the 27 treatment centers where they are dismantled and recycled (El-Kretsen, 2006). Treatment centers are chosen based on the facilities technological abilities, location, and price. In order to pay for the services, producers and importers pay fees to be a member of El-Kretsen. The fees are calculated one of three ways. Producers or importers who sell ICT products are given the actual cost of treatment each month which is then divided between suppliers according to their market share. Producers and importers of other products rely on one of two fixed fee approaches. The first fixed fee can be based on a percentage of sales values estimated for that year. If a producer or importer pays too much they are credited the next year. The other fixed fee approach is based on a number of factors including: return rate, weight, cost of treatment, materials content, and possibility of reuse. El-Kretsen does not however include a fee for historical and future WEEE (Future Energy Solutions, 2003).

The Swedish Environmental Protection Agency requires yearly data in order to monitor the country's management of WEEE. El-Kretsen is therefore responsible for

providing the authorities these figures, on behalf of its customers. Data must also come from transporters and recycling companies. El-Kretsen can perform surprise inspections on transportation and processing companies they have contracts with, to see if they are complying with the government rules. If there are issues reported, depending on the extent and seriousness of the problem, warnings, financial penalties, or termination of the contract can ensure (Future Energy Solutions, 2003).

The Swedish Environmental Protection Agency's ordinance does not provide targets. Its goal is to collect and recycle as much WEEE as possible. In 2002, 8.4 kg/capita/year of WEEE were collected. This number has continued to increase each year (Future Energy Solutions, 2003). By 2006, 15.8 kg/capita/year of WEEE were collected which was the highest amount collected for all of Europe (El-Kretsen, 2006).

5.3.5 Switzerland

In 1994, a voluntary take-back program was created by manufactures of office and IT equipment called "Garantie de recyclage." A consumer could pay an additional charge at the time of sale to have his or her equipment recycled when the owner no longer wanted it. The Swiss Association for Information, Communication and Organization Technology (SWICO) was created to take responsibility for managing the program on the behalf of its producers and importers. By 1997, The Swiss Environmental Protection Agency based their new regulations pertaining to the management of WEEE on this voluntary program (Envirosris, 2000). The major components of the legislation included:

- Producers and importers must have a take-back program
- Consumers are legally required to return electrical and electronic equipment to a designated location

- Local Regional Authorities have to approve the recycling companies employed (Future Energy Solutions, 2003)

Switzerland has two separate organizations responsible for recycling certain types of products for both residential and commercial sectors. SWICO recycling handles all office and IT equipment as well as telecommunications, graphics industries equipment, switchboard systems, consumer electronics and dental equipment. The Swiss Foundation for Waste Management (S.EN.S), manages household appliances, electrical tools, outdoor appliances, electrical and electronic toys, and lighting equipment (Hischier et al., 2005). Although both organizations are independent, they operate in a similar fashion with respect to collection, storage, and transportation of WEEE (Future Energy Solutions, 2003). Both organizations' programs collect an advanced recycling fee. The fee varies depending on a number of factors including the product, quality of the equipment, costs for collection, transport, and treatment. The fee is first paid by the producers and importers, and charged to the consumer. A visible fee is printed on the bill of sales with the purchase of any type of EEE. When the product has expired, consumers can return the WEEE to its point of purchase, give it to the producer or importer, or drop it off at a designated collection center. Since municipalities are not legally required by the Swiss government to set up their own collection areas, all WEEE is eventually transported to one of 16 private recycling firms that are contracted on a two-year term. In 2002, the combined efforts of SWICO and S.EN.S collected and treated 8 kg/capita/year of WEEE and by 2004 the number had reached 11 kg/capita/year (Future Energy Solutions, 2003; Hischier et al., 2005). The problem with the current system is there is no program to finance the collection and treatment of historical and orphan waste which is a requirement under the WEEE Directive.

The Swiss government does not audit the two organizations. However, SWICO annually audits the collection sites, the transportation company, and contracted recycling facilities, to ensure numbers are correctly reported. If problems exist, contracts may not be renewed or collection centers could be closed.

5.4 Criteria for a Sustainable IWM for IT-waste

Recognizing both the benefits and limitations associated with each program helps highlight options for development and management of IT-waste programs. The set of criteria used in this thesis was developed based on information found in the literature review, the five European countries WEEE analysis, and analysis of the conceptual framework. The broad principles found within the sustainability concept were integrated into the cradle to cradle (upstream) and waste management hierarchy (downstream) using the IWM concept. The themes identified for each sustainability principle were employed as a theoretical tool for evaluation and decision-making, since each principle can be applied to any situation. The broad principles of sustainability were applied to the waste management perspective using waste management hierarchy, cradle to cradle, and IWM concepts. The result was the creation of a set of sustainable IWM. Incorporating the results of the literature review and of the European case studies made it possible to identify specific criteria for developing a sustainable approach to IT-waste management (see figure 5.1 and table 5.9). This set of criteria was than tested through the evaluation of the OES program and applied to the RMoW in order to develop recommendations for the management of IT-waste.

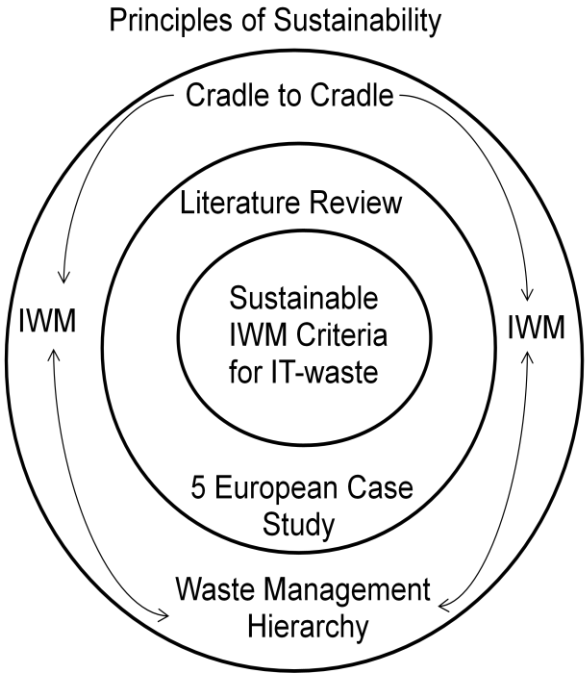

Figure 5.1 The different steps required to develop a sustainable IWM set of criteria for IT-waste

5.4.1 Example of Criteria Development

The sustainable IWM criteria set for IT-waste management consisted of 15 items. The creation of each item was based on integrating sustainable IWM points with information learned through the literature review and the 5 European case studies. Below is an example highlighting the steps the researcher took to create the first criterion— *knowledge.* It should be noted that the same technique was used for each item in this criteria set.

Step 1: Incorporating sustainable IWM points (least impacts with design and disposal) with major themes found in the literature

- Material composition (see section 4.3.3)— understanding the different materials which comprise IT equipment and its impacts on human and environmental health
- Disposal option (see entire section of 4.4)— evaluating the different management options depending on the quality of the material

- RoHS directive (see section 5.2.1)— examining what Europe has done to reduce the impact of IT products at design

Step 2: Compiling all the above information together led to the development of the *knowledge* criterion

Table 5.6 Illustration of how the criteria for a sustainable IWM for IT-waste were developed using the sustainability principles and waste management concepts

Sustainable IWM Management options (adopted from Gertsakis and Lewis, 2003; McDonough and Braungart, 2002; Seadon, 2006).	**Thesis sections informing criteria development**	**Criteria for sustainable IWM of IT-waste** (definitions below)
Decisions which result in the least impact on the social and ecological system in the management of a product from design to disposal	+ IT material composition (4.3.3) + IT disposal options (entire section of 4.4)	= Knowledge
	+ IT disposal option (entire section of 4.4)	= Behavior
	+ exporting IT (4.4.2)	= Proximity
Continue to improve product management to ensure that the safety and wellbeing of individuals are not compromised now and in the future	+ quality of IT product (entire section of 4.4 with specific attention to 4.4.10)	= Product Integrity
Consider the impacts decisions and actions have on the disposal of a product and on the health and safety of those involved in its end life management	+ identification of roles (5.2.1)	= Stakeholder responsibility
	+ supervising where and what happens to IT product (entire section of 5.3)	= Monitoring
	+ cost for managing IT waste (4.2.2; 4.4.2; 4.4.9)	=Affordability

Consider the effects decisions and actions have on product design in order to eliminate damaging impacts that will affect future generations at its end-life	+all the different stakeholders involved in a countries e-waste program (entire section 5.3)	=Collaboration
Design product with the least amount of impact by considering material composition and end of life disposal options through the integration of the cradle to cradle design principles	+ RoHS directive (5.2.1)	= Knowledge
	+ development of a provincial e-waste program (4.4.11)	= Collaboration
All stakeholders are informed and have equal opportunity in decision making regarding the management of a product and available services	+ information exchange (5.3.1)	= Education
	+ all involved stakeholders (entire section of 5.3)	= Participation
	+location and number of drop-off centers (5.3.1 and 5.3.3)	= Convenience
	+ written records for security and identification purposes (entire section of 5.3)	= Reporting
Prevent unfavorable outcomes with the disposal of a product by having incentives/disincentives in place	+ force compliance (5.3.2 and 5.3.4)	= Enforcement
Universal commitment when it comes to the management of a product from production to disposal	+ provides consistency in what is required (5.2.1)	= Standards
	+ RoHS directive (5.2.1); + WEEE Directive (5.2.1)	= Regulations

Criteria for sustainable IWM of IT-waste

- *Waste Knowledge* – takes a holistic approach to understand the underlying components within the system in order to make the most appropriate decisions when it comes to IT-waste management and the impact it has on the social and ecological system
- *Waste Behavior* – ensuring that IT is managed in a safe and controlled environment from design, manufacture, collection, transportation, disposal and treatment to guarantee the least amount of waste is produced
- *Product integrity* –IT products are examined for functionality, age, and quality in order to understand the condition of the material before waste management decisions are made
- *Monitoring*–providing accountability for where and what is happening to unwanted IT products sent for disposal
- *Education*- all stakeholders are provided with appropriate materials explaining the importance of proper design, collection and treatment of IT-waste
- *Stakeholder responsibility*- residences, manufactures, waste collectors, facility operators, and government officials all understand their role in the management of IT products in order to ensure the system functions effectively and efficiently
- *Convenience*- accessibility for all stakeholders when it comes to the collection and treatment of IT-waste
- *Standards*- standards are in place to provide consistency and effectiveness with the management of IT-waste
- *Enforcement*- rules that have been put in place are upheld through the use of a penalty system to deter inappropriate management of IT
- *Affordability*- costs are considered but are not the determining factor when it comes to decision-making for the management of IT
- *Collaboration* –stakeholders must recognize and embrace working collaboratively with one another to begin to sustainable manage IT now and in the future
- *Reporting* – documentation identifying the amount of products collected, band, and treatment is necessary to ensure products are being accounted for and managed appropriately
- *Participation*- provide opportunities for all interested stakeholders to have an equal opportunity to provide suggestions and ideas about the design, implementation, and running of a IT-waste program
- *Proximity*- IT should be managed as close to the source as possible to minimize other environmental implications caused by its travel.
- *Regulatory* – require all affected stakeholders to comply with the rules to guarantee consistency and compliance with a management program

5.5 Summary

The European WEEE directive set-out specific guidelines when it comes to producer responsibility, waste management standards, product labeling and information, and recovery and recycling rates for WEEE (see tables 5.2 and 5.3). Countries decide how to meet these guidelines, which has led to variations between these countries e-waste programs. The 5 European case study review, allowed the researcher to learn the various techniques other countries have used to manage their WEEE. For instance, countries such as Belgium and Norway have focused on establishing many drop-off locations throughout their countries to create greater convenience for their residents. On the other hand, the Netherlands has decided to focus their attention on reducing the amount of orphan and free ride products being collected. The Netherlands has created a fixed annual fee for all producers, importers, and organizations representing companies wanting to sell their EEE. All of these actions have an impact on the management of e-waste in their countries. The lessons learned from the 5 European case study help to create the sustainable IWM criteria set which was then used to analyze the OES program and evaluate the RMoW IT-waste management.

Chapter 6: Ontario Electronic Stewardship Plan Analysis

6.1 Background

On July 10, 2008 the Ontario Environmental Minister, John Gerresten, approved the Ontario WEEE program plan. The purpose of the plan was to promote the reuse and recycle of end of life (EOL) electronic items. The plan came into effect after years of planning and multiple consultation efforts held with brand owners, first importers, assemblers, sellers, industries, trade organizations, municipalities, environmental groups, community groups and the public (OES, 2008b). With approval from Waste Diversion Ontario the program will be self-managed by the Ontario Electronic Stewardship (OES) group which will be responsible for deciding target amounts, implementing educational campaigns, monitoring the flow of e-waste, and determining standards for choosing appropriate vendors to handle waste electronic and electrical equipment (WEEE). OES organization is comprised of individuals from the retail, information technology, and consumer electronics companies. The program started April 1, 2009 with information technology (IT) waste included in the first phase (information technology equipment, fax machines, televisions). The main components of the program are as followed (OES, 2008c):

- Producers and distributors are required to register and pay a fee based on the amount and type of electrical and electronic equipment (EEE) units released into the market
- For-profit and non-profit organizations, industrial, commercial, and institutional (IC&I) service providers, municipalities, retailers, reuse and refurbishing centers who collect Phase 1 material and who act in accordance with the OES Sorting and Packaging Requirements will receive:

    - $165 per tonne incentive for collection, sorting, and packaging WEEE for transportation
    - Free training material for staff
    - Free promotional and educational material
    - Free transportation to a consolidation center or processing center
    - Free equipment support (reusable containers, pallets, shrink wrap)
- OES has outlined specific management requirements for companies to follow under the Reuse and Refurbish Standards and the Electronic Recycling Standards to ensure:
    - Reliable service
    - Environmental compliancy with municipal, provincial, and federal regulations
    - Maintain workers health and safety
    - Appropriate handling of material
    - Consumer protection against identify theft
- All handlers of WEEE are responsible for tracking and monitoring collected products to provide OES data for evaluating the program for cost, location site, processing approach, and collection system
    - Collectors are to report amounts collected and location sent
    - Consolidation centers are expected to assess packaging reliability, confirm unit count from collection site, content and weight
    - EOL processors are required to separately track and report where and what happens to each pallet load

- A variety of different channels will be used to promote and educate all stakeholders including but not limited to:
    - Media participation through newspaper write-ups, radio commercials, and television exposes
    - Posters on the side of buses, buildings, bulletin boards
    - Point of purchase informational pieces
    - Creation of a province-wide material exchange network
- A portion of the program's finances will be directed towards research and development to improve the efficiency and reduce the cost of e-waste collection, diversion, tracking and monitoring of products
- Penalties for non-compliance of the Act may result in:
    - A fine of not more than $20,000 for each day of the offense for an individual person
    - A fine of not more than $100,000 each day of the offense for an organization

The OES program has taken a participatory approach. Three scheduled workshops and a variety of webcast were held in which issues associated with the plan were discussed. All interested parties had the right to make comments on both the draft of the preliminary program plan and on the draft of the final program plan. Furthermore, independent consultation efforts were held with industry stewards, municipalities, and the general public to gain further insight about the program and the goals they hoped to achieve (OES, 2008b).

For this research, a plan analysis of the OES program was carried out since it is a potential route residents in the RMoW could use to dispose of their IT-waste. Because the program has only recently been approved very few data are available to evaluate its impacts and outcomes at this time. As a result this research focused on analysis of the program plan. Determining the internal validity of the program in terms of meeting its objectives was one form of evaluation included in the plan analysis. The second part of the plan analysis was a meta-level analysis of the objectives using the criteria (established in chapter 5). The purpose was to determine whether the objectives were appropriate and feasible and which aspects may be absent from the program, given the perspective of this research.

6.2 Internal Validity Evaluation

There are eight key objectives the program proposes to achieve once fully operational. Each objective was analyzed based on the material presented in the OES final program plan (OES, 2008a). The first paragraph of each objectives describes the provisions under the OES program and the second paragraph is an analysis of the plan.

6.2.1 Objective 1: Encourage Reduction, Reuse, and Recycling of WEEE

The OES program has planned several different initiatives to encourage reduction, reuse, and recycling of WEEE. First, educational and promotional campaigns were used to inform the public about the dangers associated with WEEE, provide information regarding the different OES services, and promote appropriate WEEE disposal options. Second, cost to dispose of WEEE will now be the responsibility of the producers and not the consumer. Third, an increase in the number of avenues (municipal centers, retail stores, producers, special collection day events, and second-hand organizations) for drop-off WEEE will

provide increased accessibility and convenience. Finally, all approved processors will be required to meet identified standards for the disposal of WEEE (OES, 2008a).

All these actions answer the question of "how" WEEE will be collected but fail to provide any guarantee that it will be collected. Although OES may try to encourage reduce, reuse, and recycling of WEEE there is no outright ban outlawing disposal in landfills or incinerators. Rather OES is relying on a voluntary approach for citizens, collectors, and manufacturers alike to consciously make the choice and effort to use the services OES offers. The OES assumes that retailers and municipalities will want to become collection sites and that consumers will want to dispose of their EOL e-waste. If there is no voluntary participation there will be no program. The plan is written as if participation is already guaranteed, but it is not. For example the plan suggests collection target amounts 5 years forward, but is vague about how these targets will be met. Thus the WEEE program plan appears to fall short of its first objective. It encourages proper disposal instead of requiring compliance. The program also fails to explain how the program plans to reduce WEEE.

6.2.2 Objective 2: Financially Support and Increase the Number of Collection Depots

In order to meet the second objective, an incentive of $165 per tonne for collecting WEEE was provided. The cost plans to cover (OES, 2008a, p.51):

- Space required for pallets to hold WEEE based on market lease rate of $5.82 per square-foot;
- $20 per hour for assembling pallets roughly taking 1.5 hours to complete
- Operating costs for utilities, maintenance and insurance at 50% of the lease rate;
- Consideration for amortized capital costs needed for handling;
- Various material costs;
- Profit margin of 10%; and
- Average pallet and bulk bag weight of 300 kg.

OES decided that this incentive was adequate to cover all costs associated with collection. To be eligible to receive this financial incentive, collectors and collection sites are approved by OES and must follow requirements for collecting, sorting, and transporting WEEE. The OES believes that by providing this financial incentive it will allow more municipalities, second-hand outlets, retailers, and corporations to either hold collection day events or become permanent collection depots to create more drop-off WEEE locations (OES, 2008a).

The report tends to focus on the ease and financial incentives for being a collection depot rather than the associated dangers. Collecting WEEE is considered a liability since it is classified as hazardous material, if the equipment becomes damaged (WDO, 2005). However, limited requirements are found in the report when it comes to where pallets can be placed, what type of exposure (temperature and weather) pallets can handle, and how WEEE material should be packaged. The report also fails to state who is responsible and what rehabilitation measures are in place if improper handling of WEEE leads to air, land, and water contamination for collection sites. A further issue is that the program outlines only one type of approach to collecting WEEE. The drop-off or take-back approach requires that individuals have some form of transportation to get their WEEE to a designated location. Consequently this type of approach excludes certain parts of the populations from participating in the program. Individuals without personal transportation may be less willing to make the effort.

6.2.3 Objective 3: Double Recycling and Divert Hazardous Materials from Landfill

OES has implemented three different documents to guide the recycling of WEEE. *OES Electronic Recycling Standard* sets out recycling requirements to protect the environment as well as workers health and safety. *OES Recycling Standard Guidance Document* is an educational document that reviews all factors for assessing recycling processors. The *OES Recycling Qualification Process* is a guideline for inspectors to adhere to when it comes to auditing (OES, 2008a).

All three of these documents specify standards to ensure appropriate recycling of WEEE. They are vague, however about recovery rates. Recycling is only as good as the recovery rates obtained. Recovery rates of material can range anywhere from 50% to 90% depending on the type, age, and processing system used (OES, 2008a). Although OES wants to double recycling of WEEE, it means very little if the recovery rate is not identified as well. For example if a product has only 50% of its material recovered it means the other 50% will be sent for final disposal. It is false to assume that when WEEE is sent to be recycled, 100% of the material will be recycled. Achieving 100% recycling is difficult because of the complexities associated with the materials that comprise EEE (Envirosris, 2001). Better identification needs to be provided within the report when it comes to recovery rates versus recycling rates.

6.2.4 Objective 4: Implement Qualification Standards for Vendors

To be an OES-approved EOL processor several conditions must be met including (OES, 2008a):

- Processors may not export WEEE to countries that are not members of the Organization for Economic Co-Operation and Development (OECD) unless they can prove the processor meets or surpasses Ontario requirements for environmental, health and safety standards
- Primary processor must provide documentation showcasing that processors uses downstream also comply with the Electronic Recycling Standards
- Processors must follow all local, provincial, and national regulations and international obligations, including the *Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal*

All of these requirements are in place to ensure the utmost care is taken when handling, reusing, refurbishing and recycling WEEE materials either in or outside of Ontario. When evaluating processors, OES places most attention (70%) on processing performance and capacity requirements. Minimal attention (10%) is given to the cost associated with transporting WEEE (OES, 2008a). These figures were the weighted criteria used to evaluate WEEE processors. Objective 4 is concerned with protecting the environment. There are limited provisions in place however, to prohibit vendors from transporting this waste all over the world. The further the distance traveled, the larger the environmental costs are on resource depletion, pollution, and habitat destruction. Furthermore there are greater chances for accidents to happen because of weather and mechanical problems or human error. Transporting WEEE around the world can be as dangerous as not processing the material at all. Minimal attention is given to this issue.

6.2.5 Objective 5: Track and Monitor WEEE from Collection to Final Disposal

All stakeholders sorting and packaging WEEE (consolidation centers) are required to report to the OES the number of items collected and pallets filled. The OES distributes shipping tickets for tracking and payment purposes. The goal of this system is to analyze the

program on an annual basis in order to: identify collected materials; how (special collection day events or drop-off) and who (municipalities, second-hand organizations, producers, or retailers) collected it; and what processing methods were used to dispose of the WEEE. Monitoring the program allows the OES to isolate problems as well as set targets to better manage WEEE the following years (OES, 2008a).

Consolidation centers are the 'middleman' between collection and processing. Although they provide accountability regarding what happens to WEEE, they also reduce the efficiency and increase the costs of the program. Consolidation centers require additional workers, space, and time to unpack and repackage material. An alternative is to have collector record figures and send their waste for processing directly.

6.2.6 Objective 6: Educate Ontario Residents through Campaigns and Promotions

All stakeholders will have promotion and educational (P&E) material available to them to ensure proper management of WEEE. OES will create and distribute informational material and hold training events for collectors, transporters, and processors, while residents will be provided with a P&E campaign to identify services available to them. The report reviews different methods (newspaper, radio and television commercials, signs, pamphlets, and mailings) that will be utilized to transfer the information (OES, 2008a).

What the report fails to consider is how it will be able to reach a diverse population with respect to age, ethnicity, income, and educational abilities (Ministry of Finance, 2006). Questions that need to be considered but were never identified within the report are: What languages will the written and spoken material be transcribed in? Is there information that directly speaks to individuals with limited mobility? Is there material for all age groups and

educational abilities? Where and how can individuals get their concerns answered? All of these questions are important.

6.2.7 Objective 7: Investigate and Develop Ways to WEEE Management

A portion of the money collected from producers and distributors fees will be directed towards exploring new ways to manage WEEE. After the first year the fees will be reassessed to determine whether adequate funding has been generated for research and development. The goal of investing time, money, and energy into new ways of management is to enhance the effectiveness of WEEE collection and diversion. OES realizes that it is important to continuously try to improve by learning from others mistakes and successes, running pilot projects with new technologies, and assessing one's own system to identify where problems lie (OES, 2008a).

The report does not indicate whether efforts to improve WEEE management will give needed attention and resources to issues and aspects discussed in objective 6, for example educating different levels of ability. Furthermore, the program is only interested in EOL management and not improving product design. Understanding where resources are being divided ultimately will influence how WEEE will be managed in the future. If resources are only going towards EOL management, it is not eliminating the problem but rather prolonging it. Resources must be directed towards each aspect of the system for a permanent solution to occur for the management of WEEE.

6.2.8 Objective 8: Producers and Distributors Should Pay the Cost

The Ontario WEEE report states that producers should take responsibility for products they have created. Brand owners, first importers, and manufacturers of EEE are

legally required to register and obey the rules of the OES. Any producers, sellers, and exporters of EEE products can pay annual fees to be a member. Membership ensures that the company is complying with requirements of the Ontario WEEE program plan and that their products are being managed appropriately. If a producer wants to take direct responsibility for managing its own products they must apply to Waste Diversion Ontario or to the Minister and receive approval for an Industry Stewardship Plan (ISP). Both forms hold producers financial responsible for the management of WEEE (OES, 2008a).

The report speaks little about who is responsible for orphan waste, stating that only a small quantity of orphan waste is believed to be present and will not cause a lot of problems. Since remanufacturing and retail reporting was never required until the development of this program, it is difficult to understand where this conclusion comes from. There are also some questions when it comes to fee rates. Although fee rates have been calculated depending on the type of EEE it does not say whether the fee is paid by both the producer and distributor or somehow split between both. Furthermore, there are no universal standards for who is obligated to pay these fees. Individual companies and their retail companies can decide whether to pass their cost along to the consumer (in the form of an environmental handling fee) and what percentage consumers will be charged. These questions are important since consumers will undoubtedly be affected somehow whether the fee is hidden or not, paid upstream or downstream. Finally, it was unclear in the report how OES will ensure rules and fees are being met and how penalties are being handed down. All of these issues affect this objective.

6.2.9 Closing Remarks

The OES report tends to focus on addressing the current WEEE situation rather than taking preventive approaches to minimize or even eliminate WEEE in the future. The report relies on reusing, refurbishing, and recycling to solve the current WEEE crisis. It does not take a long-term approach to promoting design of products with the environment in mind and trying to change public attitudes. The report provides many explanations about the hazards of WEEE and the different ways to dispose of it. What it does not do is provide clear answers to how the 8 objectives will be achieved. The program promotes awareness about the issue but does not truly solve the management problem for future generations. With the program having already started April 1, 2009 little material thus far has been presented to the public.

6.3 Meta-level Analysis

The objectives identified within the OES report address many of the sustainable IWM criteria. Items that correspond both in the OES report and criteria are identified with a plus sign in table 6.1. There were some aspects not mentioned in the report but outlined in the criteria that are important and need to be considered. These items are marked with an X and will be discussed below.

Table 6.1 Identifying gaps between the preliminary criteria and OES report

Preliminary criteria	**OES report**
Knowledge	X
Behavior	+ Objective 4
Product integrity	X
Monitoring	+ Objective 5
Education	+ Objective 6
Stakeholder responsibility	+ Objective 1 and 3
Convenience	+ Objective 2
Standards	+ Objective 4
Enforcement	X
Affordability	+ Objectives 1 and 2
Collaboration	X
Reporting	+ Objective 5
Participation	+ Objective 8
Proximity	+Objective 4
Regulatory	X

6.3.1 Knowledge

Continual investment in research and development does not necessarily mean that waste knowledge is being achieved. What research and development provide is information about more efficient and effective ways to reduce, reuse, and recycle WEEE (OES, 2008a). Obtaining waste knowledge goes a step beyond an exterior solution design and instead tries to gain a holistic understanding of the underlying components that influence WEEE management. For example, if manufacturers and retailers are focused on profit, this focus may lead to cheaply made products with shorter life spans. Advertisements have created a philosophy that newer is better. A wasteful society discards equipment that still is operational (Saphores et al., 2006). Waste knowledge is about recognizing and understanding these attitudes and behaviors in order to identify how we have reached this current state and what is required of us to move towards a more sustainable approach in the future.

6.3.2 Product Integrity

Products slated for disposal oftentimes still work or have working components that are valuable to collect. Examining the functionality, age, and quality of products sent for disposal should be considered a priority for currently managing e-waste. Although the first objective of the OES is to encourage reduction, reuse and recycling of e-waste, it is ultimately up to the resident whether he or she chooses to use the reuse or recycling services provided by the OES program. Furthermore the OES program only focuses on waste minimization strategies instead of looking towards eliminating waste altogether through better product design. Promotion and investment in products designed for easy disassembly and modification is one step towards zero waste (McDonough and Braungart, 2002). Creating products that can be modified to meet consumer's needs as they continue to evolve means less waste to manage and resources needed to build new products. Short-term solutions are about separating products based on the disposal category they best fit under. Long-term solutions are about designing products where there is no waste.

6.3.3 Enforcement

OES has created a number of rules for managing WEEE and has developed ways to monitor these rules. Manufacturers, collectors, transporters, and processors are all required to track products that are in their possession. Documenting this information provides a way for OES to identify and determine if rules are being followed. Fines for non-compliance are the only form of punishment identified. There is no discussion regarding degrees of punishment depending on the extent and seriousness of the problem or who is responsible for enforcement and collection. Fines are set for non-compliance but enforcement measures still

need to be developed. Creating a penalty system that promotes appropriate behaviors instead of hinders the success of the program should be a priority.

6.3.4 Collaboration

Within the OES program, it appears that each stakeholder group is independent, with its own specialized form of instructions. For example, residents are responsible for providing the product for management. Collectors and transporters are accountable for ensuring WEEE is properly collected, sorted, recorded, and shipped to its designated location. Processors are accountable for how and where WEEE is processed (OES, 2008a). All of these stakeholders have specific knowledge in their particular area of management but have not been given a full sense of all the processes involved. All stakeholders should have an understanding of where they lie within the larger WEEE system and how their actions can impact this system (McCarthy, 2007). Collaboration allows for knowledge and ideas to be shared in order to ensure the most appropriate decisions are being made when it comes to the management of WEEE.

6.3.5 Regulatory

Employing a voluntary approach leaves it up to the individual where unwanted electronic equipment will go. OES has decided to employ this form of WEEE management which has led to uncertainties. A regulatory approach on the other hand creates standards to enforce compliance. Legally banning WEEE from landfills and incinerators forces residents to use the services already implemented. Establishing these universal regulations will ensure consistency with how WEEE is managed by employing fines and penalties on non-compliant

parties. It also allows for products to be accounted for and managed in the most appropriate manner available (Schmidit, 2002).

6.4 Conclusion

The OES objectives provide specific short-term actions to manage WEEE. How these objectives will be achieved raises some important questions. OES takes a voluntary approach to promote proper management of WEEE. There are no bans prohibiting the waste from going to landfills. While OES has created a P&E campaign and has tried to create more drop-off sites for convenience it is ultimately up to the public to decide if they want to utilize these services. The OES program is a start in the right direction but there are many issues which still need to be worked out and some important areas for further development.

Chapter 7: Regional Municipality of Waterloo (RMoW) Case Study Results

7.1 Background

This chapter presents all the data collected from the case study using documentation, archival records, direct observations, and interviews.

7.2 Documentation

The purpose of documentation was to provide background information on the RMoW waste management program as well as to ensure consistency in the data with the other methods used in the case study. Description of the study site, waste management history, cost, waste management operations, programs, bans, e-waste program, and education were all categories examined.

7.2.1 Description of Study Site

The RMoW was established in January 1, 1973. It is located in south-western Ontario, Canada (see figure 7.1) and is comprised of three urban municipalities (Cambridge, Kitchener, and Waterloo) and four rural townships (North Dumfries, Wellesley, Wilmot and Woolwich). The total area of the RMoW is 1,382 square kilometers and the 2008 estimated population of 533,700 (Region of Waterloo, 2006; Region of Waterloo, 2009).

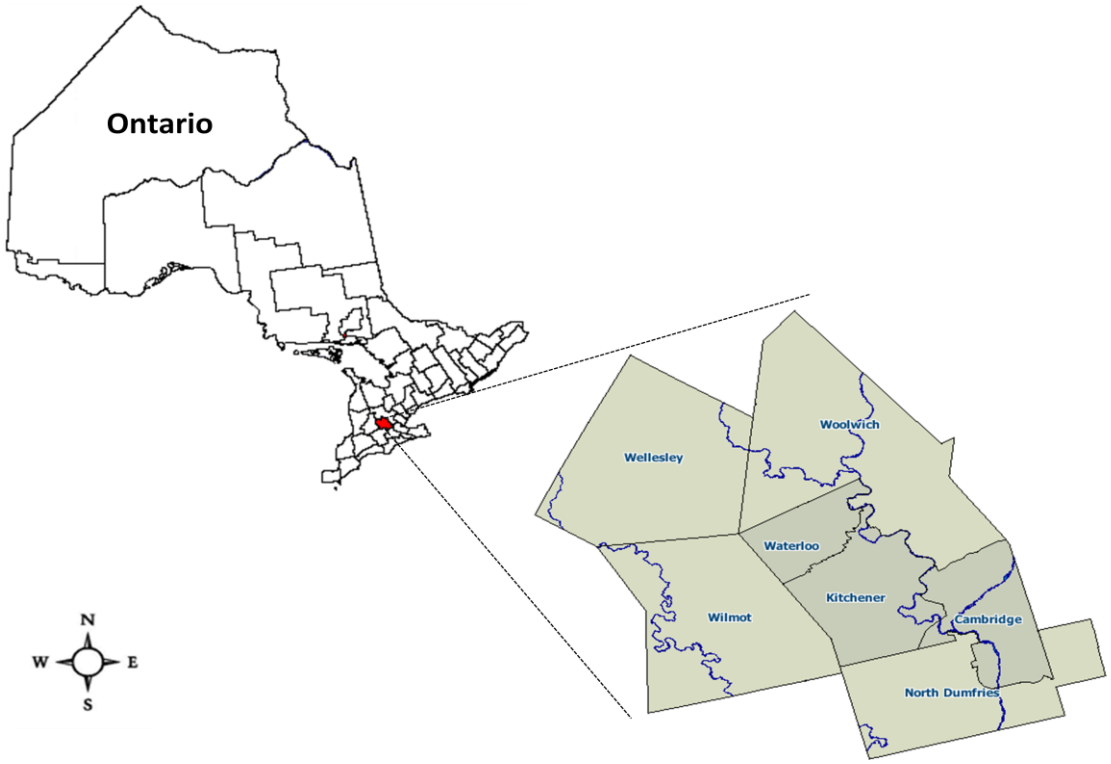

Figure 7.1 A map of the RMoW
Maps modified from Region of Waterloo locator (2008) and Nationmaster.com (2005).

7.2.2 RMoW Waste Management History

When the RMoW was formed in 1973, it assumed full responsibility for waste management site operations and solid waste disposal. However, waste collection remained the responsibility of each municipality and township. In January 2000 the RMoW took control of all waste collection including curbside collection for garbage and recyclables in order to eliminate service fragmentation and enhance performance. Table 7.1 identifies RMoW responsibilities for waste management (Region of Waterloo, 2006, pgs. 7.1-7.2).

Table 7.1 RMoW waste collection programs for cities and townships

Cities	Townships
Weekly curbside garbage collection	Weekly curbside garbage collection
Weekly curbside blue box recycling collection	Weeklyor Bi-weekly curbside blue box recycling collection
Weekly white goods and large item pick-up	Large item pick-up in some townships
Christmas tree collection	Christmas tree collection in some townships
Bi-weekly yard waste collection	
Drop-off used oil collection program	

The RMoW has taken a proactive approach with waste management initiatives. Many programs have been implemented without assistance or instruction from the provincial government. For example, the Region's municipal waste management facility was the first in North America to register with ISO 14001. This designation means that the "center is committed to identifying the immediate and long-term impacts of its operations, programs, and activities on the environment and taking the necessary steps to reduce these impacts" (Region of Waterloo, 2006, pg. 3.17). The RMoW was the first municipality in Ontario to market recyclables, another groundbreaking initiative. Its success has made it a model for other municipalities. The Region Master Plan boasts that Waterloo remains a model for other communities, featuring (Region of Waterloo, 2006, pg. 9.1):

- 25-30 year long-term plan in place
- Debt-free waste management operations
- One of the top diversion rates in the province
- One of the lowest total system operational costs

7.2.3 Costs

In 2007, waste was collected from 133,000 households in the RMoW. Waste collection charges are included in residential property taxes. For example, owners who have a residential property value of $203,000 paid $67.40 in 2007 (Region of Waterloo, 2007).

7.2.4 RMoW Waste Management Operations

The RMoW operates two waste management facilities in Waterloo and Cambridge, has one bulk transfer facility, four closed landfill site no longer operating, and six small vehicle transfer stations located in each rural township and at the two landfill sites (Region of Waterloo, 2006). The Waste Management Department is responsible for managing all residential waste in the RMoW and has initiated a number of waste reduction programs (curbside blue box recycling, backyard and centralized composting initiatives, permanent drop-off of certain household hazardous products, and special collection events) and has implemented waste bans (grass, tire, corrugated cardboard, wood pallet, and electronic waste), and provides educational services to help reduce the type and amount of waste sent to the landfill site(Region of Waterloo, 2006). In 2004 roughly 70,363 tonnages or 43% of waste generated in the Region was diverted away from the landfill (Region of Waterloo, 2006). All of these initiatives have help with trying to reach the 2000 provincial mandate of 50% diversion. By 2007, RMoW was still only diverting 45% of its trash away from landfills. Consequently, it have been ranked 93rd out of 206 municipalities for diversion but 3rd out of larger municipalities (Oliveira, 2009).

7.2.5 Waste Reduction Programs

The RMoW has implemented 10 different waste diversion programs for more specialized waste. All of these programs help to divert useable waste out of the landfill and into commodities that can be of use or can be remanufactured into a wanted resource. For the purpose of this study the e-waste recycling program was examined (see table 7.2).

Table 7.2 List of waste diversion programs in the Region

Program	Products	Purpose
Blue box	Paper products, plastics, glass, cans	Save landfill space while turning the material into new products
Organics waste collection	Yard waste and household organic materials	Save landfill space and turn material into compost
Household hazardous waste program	Batteries, cleaners, paints, pressurized tanks, aerosol cans, pesticides, and medicine	Prevent dangerous materials from leaching into landfill
Bale wrap recycling	Polyethylene agricultural bale wrap	Used to wrap forage in farm fields
Bicycle reuse	Bicycles	Refurbish bicycles to save landfill space and promote clean transportation
Building material (Partnership with Habitat for Humanity)	Appliances, cabinetry, doors, electrical, flooring, hardware, insulation, lumber, plumbing, windows, furniture	Salvaged building materials being resold and proceeds go to habitat for humanity projects
Electronic waste recycling	Computers, monitors, speakers, radios, fax machines, VCR, DVD, etc.	Recycle/refurbish e-waste
Ink cartridges and cell phones	Ink cartridges and cell phones	Donated ink cartridges and cell phones equals food for the food bank
Rechargeable batteries program	Rechargeable batteries	Diverted from the landfill and turned into stainless steel products
Textile recycling (partnership with Goodwill)	Clothing, footwear, accessories, toys, book, household items, etc…	Proceeds from products sold go to help job training programs

7.2.6 Bans

Waterloo Region has banned 5 items from its landfill. The Region provides some sort of program or service residents can use to ensure the product is properly being managed. For the purpose of this study the electronic waste ban will be the only one examined below (see table 7.3).

Table 7.3 Waste bans initiated in the region of Waterloo

Ban	**Product**	**Purpose/service**	**Fee**
ER-88-110.1 Disposal of Waste Tire Ban	Vehicle tires	Regional transfer stations collect and recycle tires	Loads exceeding 50 kg, $10 per 100 kg
ER-02-125 Old Corrugated Cardboard landfill ban	Corrugated cardboard	Blue box program recycles and sells the material	Loads exceeding 50 kg will be $3 / 100 kg
E-02-072 Wooden Pallet Landfill Ban	Wooden Pallets	Waterloo and Cambridge facilities turned pallets into mulch which is either donated or sold	Loads exceeding 50 kg, $3 per 100 kg
E-02-070 Curbside Garbage Collection of Grass Ban	Grass Ban	Grass is collected and turned into compostable material	Loads exceeding 50 kg, $3 per 100 kg
E-04-092 Landfill and Curbside Waste Collection of Electronic Waste	Computers, monitors, laptops, printers, scanners, VCRs, DVDs, fax machines, photocopiers, audio/video equipment, stereo speakers, radios	Divert hazardous products out of landfill space and send it to be recycled	$10 for the first 4 products, $25 for each additional item

7.2.7 E-waste Program

The RMoW Council initiated the first ever e-waste collection day in the fall of 2004. The following year permanent drop-off facilities at Waterloo and Cambridge waste facility made possible for a ban to be passed. On June 6, 2005 the *E-04-092 Landfill and Curbside Waste Collection of Electronic Waste Ban* was enacted. It prohibits e-waste collection at curbside, or disposal in the landfill. Instead a sticker is placed on any e-waste equipment found on the curb explaining the program and what is required. Residents can either find their own company to dispose of e-waste or can go to Waterloo or Cambridge waste transfer station and pay the fee. The charge helps to cover the cost of transporting and recycling the equipment. There are no charges on small electronic items such as keyboards, mice, cell phones, and pagers (Waterloo Waste Management, 2004). Although there is no specific e-waste coordinator, the developer of the e-waste ban still oversees the e-waste program.

7.2.8 Education

A number of educational programs have been implemented to promote proper waste management behaviors. "The only cure for litter is you" campaign educates about and promotes the importance of the 3Rs to all ages. It uses a number of different media outlets including: the Regional website, brochures, telephone directory, bumper stickers, posters, and radio commercials to get its message across. Several workshops are also held every year to assist residents with their composters. For children an environmental educational program called "catch a bug" has also been created. The program goes to different schools and uses hands-on activities to teach appropriate waste behaviors (Region of Waterloo, 2006). These programs promote better ways to manage waste without putting restrictions on age or ability.

The Region has invested in an environmental educational center, an educational coordinator, and numerous advertisement outlets to create and disseminate information out to the public (Region of Waterloo, 2006).

7.3 Archival Research

The purpose of using archival records was to identify the amount and direction in e-waste collection totals for the RMoW. Comparisons with other Regional Municipalities were also made to see how the RMoW measured up in collection performance to other areas. All the information came from Waste Diversion Ontario.

7.3.1 Data

The data showed a rapid jump from 2004 to 2005 while e-waste totals rose slightly from 2005 to 2006 and dropped-off minimally in 2007 (see figure 7.2). Estimation of IT-waste weight totals were calculated using the yearly e-waste figures and multiplying them by 10%. This percentage was used because it was determined from the literature that 10% of e-waste is comprised of IT-waste (see figure 7.3) (CSR et al, 2005).

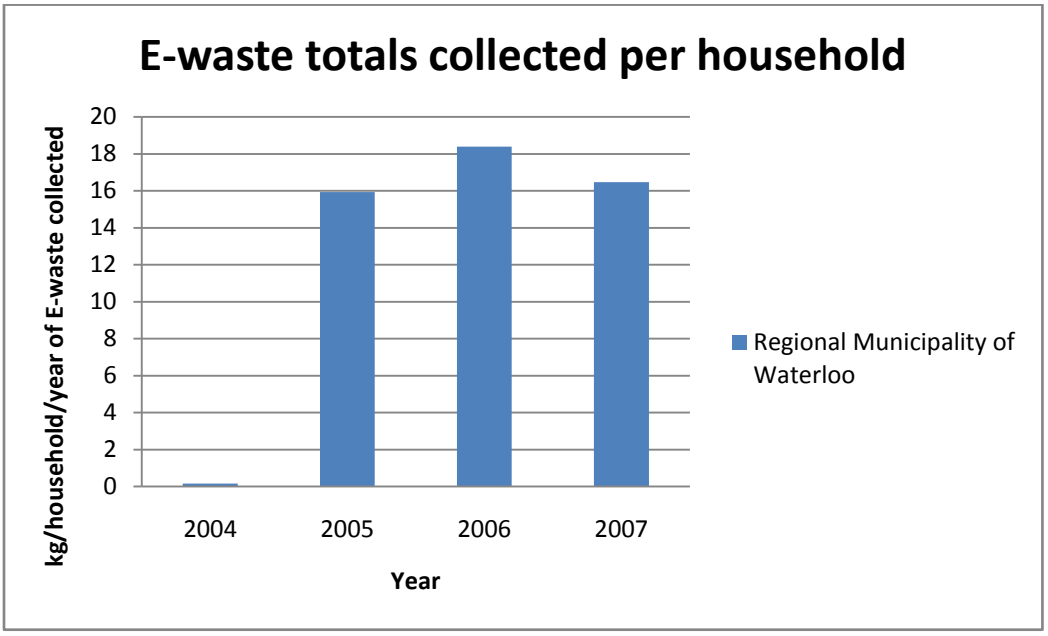

Figure 7.2 Annual totals of e-waste collected per household in the Region of Waterloo (Source: Waste Diversion Ontario, 2007b)

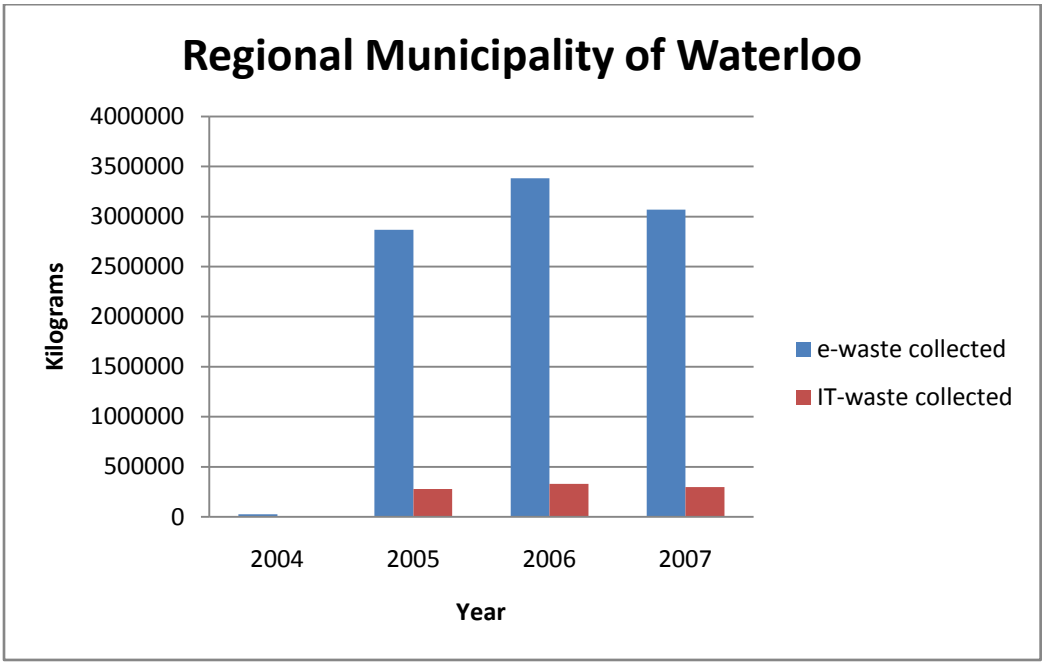

Figure 7.3 Actual totals of e-waste collected and estimated IT-waste amounts for Waterloo Region (Source: Waste Diversion Ontario, 2007b)

Comparisons were also made between RMoW and other Regional Municipalities e-waste recycling totals. RMoW had higher totals compared to other Regional Municipalities even though Waterloo did not accept navigational, measuring, medical and control equipment (see figure 7.4) and charged a fee for collection. The results indicated that other Regional Municipalities e-waste programs all had similar collection total numbers while the RMoW doubled the amount of kg/household/year of e-waste collected.

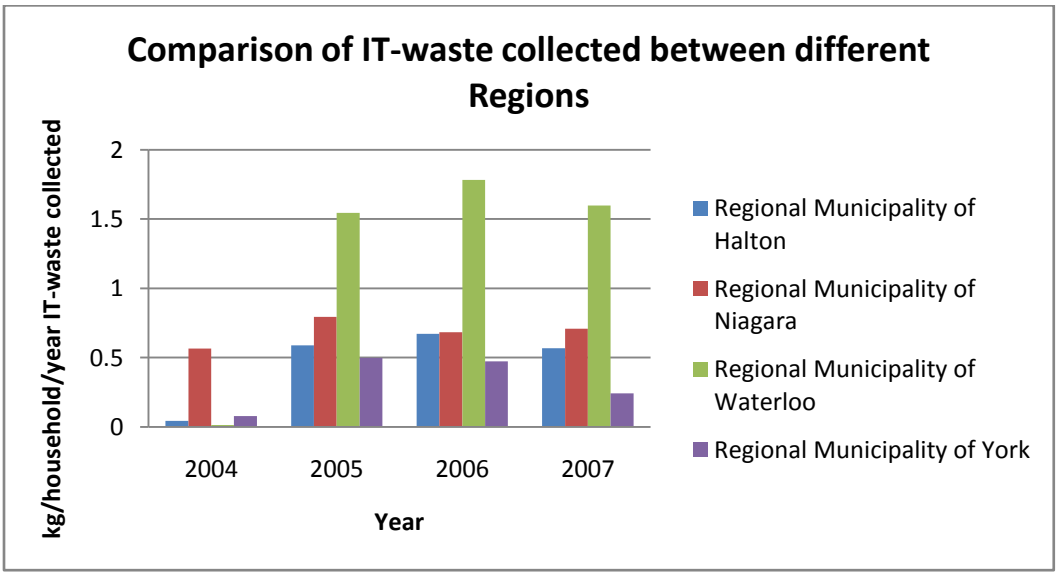

Figure 7.4 Comparison of e-waste collection totals from different Regional Municipalities in Ontario (Source: Waste Diversion Ontario, 2007b)

7.4 Observations

The purpose of carrying out observations was twofold: first, to understand what is currently required by residents to dispose of their IT-waste; and second, to understand how EOL IT-waste is managed at each facility. A description of location, site design, and employees behaviors were recorded at each location. As noted above, one observation at

each location was sufficient since the guide at each facility stated what was witness is consistent with what happens daily.

7.4.1 Region of Waterloo Location

A single observation took place on March 2, 2009 at the Region of Waterloo Waste Management Facility located at 925 Erb Street West, in the city of Waterloo Ontario. This observation session went from 11:15 to 11:45 am. The researcher and a worker from the Region sat in a van away from the direct flow of vehicles traffic to inconspicuously observe the disposal procedures.

7.4.1.1 Site Design

The small vehicle transfer site was designed in a circle where there are several drop-off containers located in different points within the circle. When vehicles enter this area directly to the right were trailers (Habitat for Humanity and Goodwill) which accepted donated items. To the left was a garage where residents drop-off their household hazardous waste. There was no charge for any materials drop-off in this location. A connecting road led vehicles to another area that collected household waste items. The items including e-waste discarded in this location all had a disposal fee attached to them. At the entrance of this "fee area" there was a brick building where a facility operator was station. The job of this operator was to collect disposal fees and direct residents to the appropriate area (see table 7.5). Drop-off was only accessible by vehicle.

Table 7.4 RMoW WEEE fees

Number of Items	Cost
1 to 4 items	$10.00 each
Over 4 pieces	$25.00 each
Commercial loads	$2000.00 per tonne

The WEEE recycling area consisted of a make-shift tent. There were large metal tables where residents drop-off their e-waste. At the back and front of the tent there were large signs which indicate what items were accepted versus what items were not. The tent was enclosed on three out of the four sides. The exposed side had the option of being closed if needed. Although the tent was able to shelter e-waste against precipitation it was unable to protect it against extreme temperatures. Collapsible re-useable plastic totes where used to hold the e-waste. There were seven totes within the tent. E-waste was separated into three categories: monitors, central processing units and everything else. Once filled the totes are loaded onto one of the onsite tractor trailers (see images below). Once the trailer is filled it is transported to the Sims facility in Mississauga for recycling. There was no place to drop-off products which were still working.

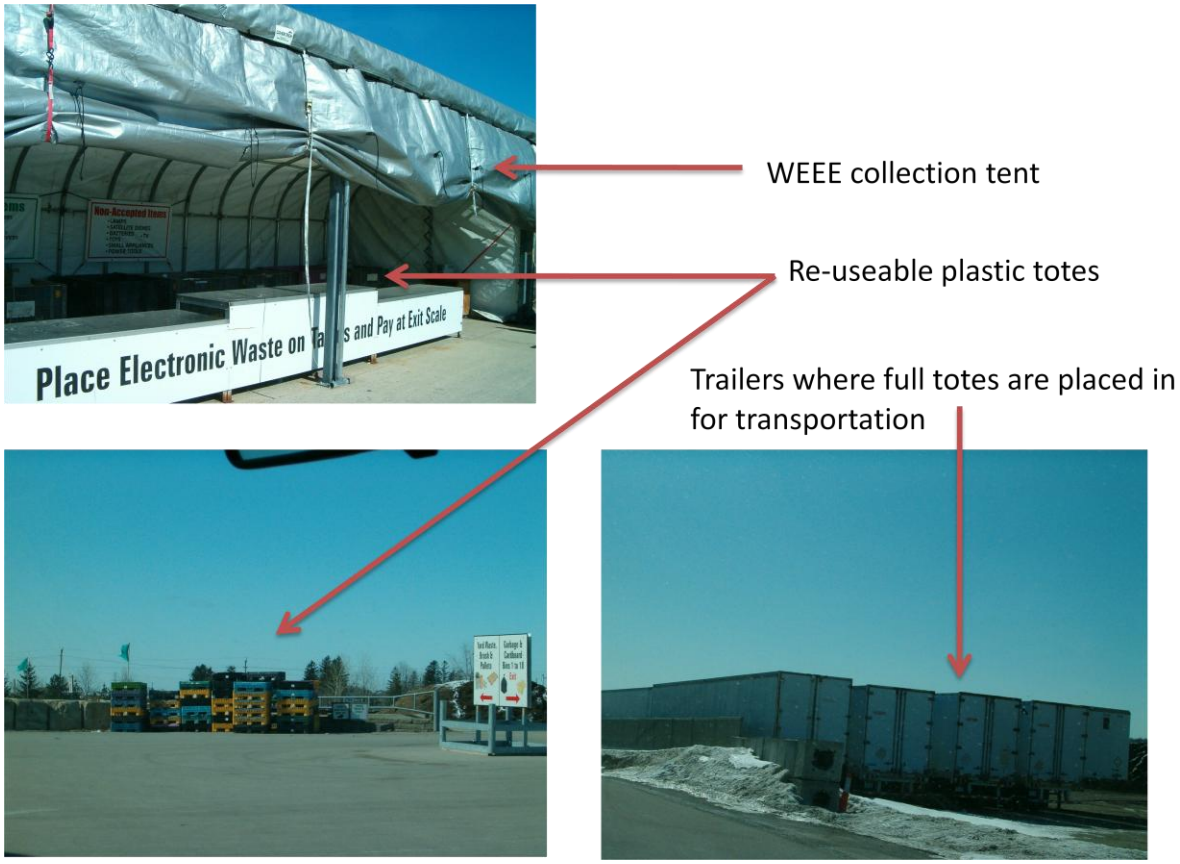

Figure 7.5 Pictures of Waterloo Waste Management Facility

7.4.1.2 Residents and Employee Behavior

While at the facility the researcher observed one individual using this service. The car drove over to the brick building to pay the disposal fee (facility only accessible by vehicle). The facility operator examined the waste material and determined the fee. The driver drove over to the tent where the individual unloaded the desktop computer onto the table and left. A few minutes later a worker came out of the brick building to move the computer waste off the table. The employee placed the monitor in one tote and the rest of the computer in another tote. The employ returned back to the building. It was decided that no further up observation

of the small vehicle transfer station was warranted. This service is only sporadically used by Waterloo residents because it is open all year round.

7.4.2 E-waste Processor Location

A single observation took place on March 24, 2009 at a recycling/reuse company that did not wish to be identified within the report. The observation session went from 8:30 to 9:00 am. The researcher did a walk through with the employee who explained the different operations that took place within the company.

7.4.2.1 Site Design

The company was located in a large open warehouse where residents can come by and drop-off their unwanted e-waste equipment. Inside the warehouse it was quite chaotic with electronic equipment stock piled all over the place. It was somewhat organized in the sense that the similar products were all kept together. There are a few work benches sporadically located throughout the warehouse where employees could disassemble products. The company relies on people instead of high tech machines to disassemble products. It was quite dark inside and there appeared to be a lot of dirt and dust all over the place. Products that have been disassembled and waiting to be sent to a downstream recycler were transferred to another area where they were placed on wooden pallets and shrink wrapped.

7.4.2.2 Residents and Employees Behaviors

There were 3 employees working when the observation took place. One aspect that became quite evident was the lack of safety equipment. Employees did not have gloves, masks, or safety goggle. It seemed that employees were allowed to eat and drink while

disassembling products since coffee cups and wrappers were seen on work stations. The demeanour of the workers appeared to be relaxed where employees went about doing their own thing. They would pick-up an item, bring it back to a bench and start the disassembly process. It was unclear where the products went, such as the circuit boards or batteries, after they were taken out of the product. During the observation session the researcher did not see any residents drop off unwanted equipment.

7.5 Interviews

Thirteen semi-structured interviews were held with individuals who somehow had an impact with IT-waste management in the RMoW. The purpose was to understand RMoW e-waste program in order to identify benefits and limitations with it. Interviews were held with individuals who worked for the waste management department and had specific knowledge with the e-waste program, RMoW councillors who enacted the e-waste ban, and e-waste processors found in the RMoW e-waste directory.

7.5.1 Waterloo Region Waste Management

Two individuals who work at the Region's municipal waste management facilities were interviewed. One was involved with the development and implementation of the ban while the other employee is responsible for the program. There was consistency in many of the responses regarding the e-waste collection program, including reason for implementation, the recycler, IT-waste trends, drop-off procedures, education and promotion, tracking and monitoring, convenience, and approaches to management. A list of the questions can be seen in Appendix C.

7.5.1.1 Reasons for Implementation

The motivation to enact Waterloo's e-waste landfill and curbside ban, was concerns over the environmental impacts associated with this material. By banning e-waste the RMoW is taking heavy metals away from the landfill and redirecting them into new materials.

7.5.1.2 Recycler

The Region of Waterloo uses Sims Company, located in Mississauga, to process all of its electronic waste. The Regional waste management coordinator explained that this company was chosen based on criteria created by the Region to evaluate the different recycling companies available. The criteria consisted of:

- ISO 14001 registered
- Have a 100% diversion rate from landfill
- Provide proof of destruction (Destruction certification)
- Downstream auditing of third-party users
- Up to date approved provincial regulation (Certification of Approval)
- Have been in business for a while

The Sims Company received the contract, even though they are the most expensive, because they were best able to meet the criteria compared to all other companies who applied. The interviewee explained that the Region was willing to take on the additional costs to ensure that IT-waste was not going to landfills or being shipped overseas.

7.5.1.3 IT-waste Trends

When asked if there has been an increase in the amount of IT-waste discarded in the past five years, both interviewees indicated yes, even with the addition of a fee in 2005. IT collection totals have increased slowly each year as the age of equipment discarded has

changed dramatically. When the program first started IT equipment tended to be 5 to 10 years old. Today products are only 1 to 5 years old. The main reason given for this dramatic turnover in age is improved performance at a minimal cost to the consumer has created this commercialized cycle.

7.5.1.4 Drop-off Procedures

Both interviewees explained that IT products brought in are not separated into different disposal options depending on the functionality and condition of the equipment. Rather when residents drop-off their IT-waste they get sorted into three different streams including: monitors, central processing units, and other small stuff (mouse, keyboard, speakers, etc.) by a worker. Once packaged into collapsible reusable totes, it is weighed and put on a truck and transported to the Sims Company for disassembly and recycling. Tracking and monitoring of these products once it leaves either Waterloo or Cambridge waste facilities are the responsibility of Sims. A certification of destruction is sent to the Region itemizing the different material and how it was processed. The RMoW relies on Sims to inform it of what is happening to the IT equipment sent for processing.

7.5.1.5 Education and Promotion

The Regional Municipal website, Environews, newsletters, signs at the landfill, and radio spots have all been different sources used to education the public about the e-waste banned. The biggest ongoing promotion has been in the front section of the telephone book, which explains all the different programs, bans, and fees. This method of advertisement not only reaches everyone in the Region but it can be updated each year and is free to the public. Even with these different avenues of advertisement both interviewees agreed that the student

population is very poor at properly disposing of their IT-waste. Since it is a transient population the feedback loop generally does not get back to the student because they are already long gone before any action can be taken. Rather the owners of the establishments where the equipment is found or the Region will absorb the cost to dispose of IT-waste found.

7.5.1.6 Tracking and Monitoring

When asked what measures are in place locally to ensure that residents are not throwing away IT-equipment with the regular garbage, both indicated different means depending on whether it is at the landfill site or at the curb. If a garbage collector can either see or feel a banned item at the curbside, it will be left and stickered explaining what is required to dispose of it properly. It is up to the residents to pick-up and properly dispose of it. At the Waterloo and Cambridge landfill transfer site the resident is specifically asked by the scale person whether he or she have any electronic waste. Spotters are located at the transfer station and carry out visual inspections. These three approaches generally are able to capture a majority of the IT-waste sent for improper disposal. Space, time, and the cost of staff presence have been identified as the main resources used to maintain and enforce this e-waste ban.

7.5.1.7 Convenience

When asked why Waterloo and Cambridge are the only waste facilities where residents can drop-off their IT-waste, the waste management coordinator explained that it is because of staffing limitations, space, and facility issues. First, all the townships except for Woolwich are open only 1 or 2 days a week because of staffing limitations. Second, they do

not have the space to hold equipment. Finally, there is no facility to hold the equipment meaning it would be exposed to the weather elements. Both agreed that this setup is not very convenient for individuals living in the surrounding townships, but there are no future plans to establish a drop-off center at any of the townships transfer station. Instead both said they hope to phase out the e-waste program and let producers, distributors, and retailers take care of electronic waste in the future.

7.5.1.8 Approach to Management

Although the Region of Waterloo uses a regulatory approach in terms of the actual ban, it also promotes voluntary action in the sense residents can choose where they want to bring their e-waste. When both interviewees were asked which approach, regulatory versus voluntary, provides the best means to manage IT-waste, both agreed voluntary. The reason given was, even if you have regulations in place, if there is not enough manpower or money for enforcement, chances are they will not be followed. Both believe that manufactures are aware of the impacts their products have on the environment. One of the interviewees stated that being identified as 'greener' can create a competitive edge against other competitors.

7.5.1.9 Regional Waste Management Coordinator

The rest of the information discussed with this interviewee pertained mostly to decision making regarding e-waste management. When asked if the Region was going to use the resources available from the OES stewardship program the response was somewhat complicated. The Region has not decided to participate because it has a number of concerns about its setup and the implications. First, the report does not delineate whether fees are visible or invisible to the consumer. Second at this time recyclers have not been identified.

Concern is over who the selected processors will be and will they be able to meet the Region's standards. Third is the use of a consolidation center which the interviewee believes is an unnecessary step since extra time and money is need to run these facilities, instead of having the waste shipped directly to the recycling center. Fourth, little mention has been given to what and where the collection points are in the Region. The interviewee explained that the $165 per tonne is too low to cover the cost of labour needed to run a collection facility. Fifth, OES is proposing to use shrink wrap and pallets to transport everything which is a step back from the reusable totes that are now used by the Region. Finally, there is concern about how much control the Region will still have when it comes to the collection of materials. The Region has always taken a wide array of materials beyond phase 1 and the concern is whether it will still be able to take them. If yes, can it still be dealt with by one contractor or will it have to be packaged differently? All of these issues have prevented the Region at this point from being a registered collection facility for the OES program.

When asked why everything is sent for complete destruction instead of sorting into different disposal options, the interviewee explained that it is too hard to test and put aside reusable from recyclables. The Region gets so many products that it is just easier and more secure that all products are sent through one channel, that being destruction. The interviewee explained that if people are not comfortable with this service they can always go to one of the companies identified in the e-waste directory to dispose of their equipment.

The interviewee stated that most individuals have accepted the ban as indicated by the fact that minimal roadside dumping has taken place. Although roadside dumping has not been a big issue, the actual identification of the perpetrator is difficult to prove because of the

lack of evidence. The amount of time and evidence needed to prove responsibility is very great. For this reason, the RMoW will usually clean up without starting an investigation. The interviewee also wanted to make it clear that the fees residents pay for recycling are nowhere close to what the actual costs for transporting, handling, and disposing of the material. Instead the e-waste program runs at a net loss for the RMoW.

When asked if e-waste could ever be a pickup item, the interviewee was doubtful because of the nature of the material and how it needs to be handled. Drivers usually throw things against each other which could damage the equipment and lead to exposure of hazardous materials. Furthermore, the amount of additional cost that would be required would result in even a greater net loss for the Region.

The interviewee was asked whether government guidelines are needed to provide standards when it comes to the management of IT-waste in Ontario. His response was it would be useful if they were well considered before being implemented and that it should not be restricted provincially but rather globally since it is an international problem. There should be consistency when it comes to the management of waste since it is not bounded by boundaries.

7.5.1.10 Manager of Operations

The questions discussed with this interviewee pertained to what he witnessed with the e-waste program. When asked if there are seasonal differences in the amount of IT-waste collected he stated yes. In the winter time there is less because people do not want to lug around this equipment when it is cold. During spring, summer, and fall there is a higher volume especially with the beginning (September through October) and end (May though

June) of the school season. When asked how residents feel about paying a fee for recycling IT-waste he said half are happy to do it while the other half are not, but most understand why they have to pay.

7.5.2 Regional Municipal Council members

Four Regional Municipal councillors out of sixteen agreed to be interviewed. All were asked 7 questions that specifically examined why the council chose to implement the e-waste ban (Appendix D). The first question asked what they believed were the driving factors that led to the ban. Three stated the desire to reduce the amount of waste going to the landfill and to remove hazardous waste from the landfill and recycle it. One went on to state that even with the ban people continue to put computers at the side of the road because they do not want to pay the fee or because of the inconvenience of having to drive to dispose of it. This council member was concerned with how many people actually hide banned products being sent to the landfill. All councillors agreed that the public is not fully informed about the dangers associated with e-waste and that education is needed.

All councillors believed that e-waste is useful to the community if people followed the rules and recycle their e-waste. When asked if the ban took money away from the council's budget, 2 of the councillors said no, while the other 2 councillors did not know. All agreed that there is a need for provincial government guidelines to provide standards when it comes to the management of e-waste in Ontario. However, one councillor went on to say that although it provides consistency amongst all, the rules do not necessarily take into consideration the individual needs of each municipality, which can cause issues. Although the councillor was unable to give a specific example he did stated that government standards

"might be great for Toronto but does not work for the Region of Waterloo." There was also complete agreement that the ban would continue to be in place in the future.

The Regional Municipal councillors have the power to decide whether or not a ban will be implemented. Councillors will read reports (e-waste diversion report), listen to public concerns and rely heavily on staff advice before a decision is made. One of the councillors added that she has been lobbying to have implemented a curbside e-waste collection program. The councillor believes that this would lead to greater participation if it was more convenient for residents to dispose of this waste. One of the councillors, who was also the mayor for one of the townships, stated that no one has ever personally complained about having to go either to Waterloo or Cambridge to drop-off their e-waste.

7.5.3 E-waste Processors Interviews

Twenty e-waste processing companies were contacted and asked to participate in the study. They were found on the RMoW e-waste directory. This directory was created to list alternatives if individuals did not want to use the services provided by the Region. Seven companies responded. One was no longer in business and did not answer a majority of the questions (see table 7.6). A list of the questions can be seen in Appendix E.

Table 7.5 Interview responses

Company	IT-waste accepted	Disposal Approach for Recycling	Reuse/Refurbished	Certification of Approval	Registered ISO 14001
1	Any type	Disassemble	Yes	No	No
2	Any type	Disassembly and Storage	Yes	No	No
3	Any type	Disassembly	Yes	Yes	Yes
4	Any type	Disassembly and Shredding	Yes	Yes	Yes
5	Any type	Disassembly	Yes	No	No
6	Any type	Disassembly and Shredding	No	Yes	Yes
Out of business	Any type	Disassembly	Yes	No	No

7.5.3.1 Disposal Approaches

Each company has its own way of managing IT-waste. The first five companies stated that they test all the equipment that comes in and separates it into either reuse or disassembly. Respondents 1 and 4 assured the researcher that all products sent for reuse and refurbishment stayed in North America. Companies 3 and 5 indicated that sometimes products would be sent overseas. One of the interviewees explained that selling working products extends the life of the product because there is an outside market that is willing to pay for this used equipment. All 4 of these companies also disassembled products for recycling. Companies 1, 3, and 5 have employees disassemble equipment into glass, metals, and plastics, which are then sent for downstream processing. Company 4 goes a step beyond disassembly and actually shreds up the material before it is sent to downstream processors.

The interviewee from company 2 explained a somewhat different reuse program compared to all the other companies. He disassembles products and sells the useable components found inside the equipment. Materials collected from disassembly are stored and usually not sent downstream for processing for fear it will be shipped overseas. The interviewee explained that IT products will not leave his company "unless it gets shipped directly to someone who remanufactures or actually processes the material and uses it" (Company 2 employee, 2009). In the past he used downstream processors but was certain that some of the material was being sent overseas to China for recycling.

All five of these companies were asked how they were able to separate reusable equipment from recyclables given that municipalities indicated that they were unable to do so because of time and resources. Company 1 stated that another company has had to come in and subsidize the finances to allow for testing and separation of reuse from recycling. Company 2 believed it is more of an excuse or lie of not wanting to put the effort or time into it. Company 3 discussed the economic gamble of testing equipment. The interviewee gave the example that you may have to test 100 computers in order to find one that actually works. Even if you have equipment that works if there is no demand it is worthless in the reuse market. Companies 4 and 5 both stated that municipalities are not set up and do not have the workforce to automatically check every product that comes into their facility.

Company 6 did not have a reuse program. It is instead an company that disassembled and shredded all products that come into its facility whether they were workable or not. The company decided not to have a reuse program in place for security purposes in order to protect their client.

Recycling does not take place at any of these facilities. Rather the job of these companies is to disassemble and sort products into different materials before they are sent to downstream companies that specialize in a particular type of recycling. All companies stated that they audit their downstream processors to ensure recycled material is not being shipped overseas. Table 7.7 shows what percentage of a product gets recycled at each company. All companies who responded to this question had comparable recycling totals which were high.

Table 7.6 Percentage of equipment recycled from each company interviewed

Company	Recycling percentage
1	95%
2	?
3	95-98%
4	98%
5	96%
6	95%

7.5.3.2 Standards

A Certification of Approval is required for any company that "stores, transports or disposes of waste" (Ministry of the Environment, 2007, pg 1). The owners of these facilities are legally required to apply to the Ministry of the Environment if they wish to manage waste. The purposes are to ensure compliance of environmental laws, protect human and environmental health, and educate applicants (Ministry of the Environment, 2007). Four of the 7 companies interviewed did not have their Certification of Approval. When asked why their company did not have the certification, there were a number of responses. Company 1 stated that they did not need it because they do not disassemble hazardous materials. Company 5 said they did not need it because they were not shredding the products and

emitting hazards into the air or water. Company 2 said that it is up to the owner whether they want to join or not. Company 6 which has the certification stated that because there is no enforcement from government, companies usually will not take the time or effort to apply. It was interesting to note that companies that had the Certification of Approval were also registered ISO 14001. Being registered ISO 14001 is a voluntary initiative for companies who wish to go beyond complying with regulations. A company must:

- Maintain and improve an environmental management system
- Develop and follow its own environmental policies
- Demonstrate compliance
- Follow already existing environmental laws and regulations
- Have an external third party analyze its environmental management system for certification
- Self evaluation of compliance

If a company is able to satisfy all these requirements they can be registered ISO 14001 (Environmental Management Guide, 2002).

7.5.3.3 Security

There are two ways to ensure sensitive material found on IT equipment is destroyed, physical destruction or software wiping. Companies 1, 5, and 6 all physically destroy the hard drive to ensure material cannot be gathered. Company 2, 3, and 4 all use a software system that zeros the hard drive and renders the information unreadable. Zeroing the hard drive allows the equipment to still be used, while the other approach requires a new hard drive to be installed.

7.5.3.4 Design

All were asked how much of an impact designs have on disposal. Most indicated that there are differences in dismantling but it is not significant. Interviewee from company 6 believed otherwise. He stated that there is no consistency between manufacturers and their products. He indicated that there is very limited to no communication between recyclers and manufacturers when it comes to IT equipment design. Consequently, one manufacturer may use Philips screws while another one may use Robertson. Screw placement and number of screws is different between each manufacturer. Switching between different screw heads and looking for screws takes time away from workers trying to dismantle products. The interviewee believed "if manufactures all use the same type of screw in the manufacturing process it would be a lot easier for us to manage, a lot cheaper in the long run." Furthermore, the screws could be reused instead of sent for recycling because there would be a market for them.

7.5.3.5 Management

Several different questions were asked about the management of IT-waste. Questions included:

1. Do you keep records of the sources and end destinations of IT equipment that comes into your business?
2. What is the condition and age of collected IT equipment?
3. Do you charge a fee?
4. How much of your business comes from the residential sector?

The answers from each company can be seen in table 7.8. The responses to the questions were straight forward except for the fee question. All companies except for 2 would be participating in the OES program as a collector and therefore would no longer be

charging a fee after April 1, 2009. However, when the interviews took place the program had not started and fees were still being collected. The age and condition of equipment was one area where there was some variation between respondents. In the case of company 1, it typically saw IT equipment which was 9 years or older and did not work. Company 5 tended to see much newer IT equipment. Another area where differences lied was companies cliental. Smaller independent IT processors such as companies 1 and 2 received more business from the residential sector compared to larger processors whose main cliental included industries, corporations, and institutions.

Figure 7.6 Responses from some of the interview questions

Company	**Records**	**Quality**	**Fee**	**Residential**
1	No	-Not really working -2000 and older	No	50%
2	No	?	Yes $8	33%
3	Yes	-10 years for recycle -5 years for reuse	Yes for recycling	Less than 1%
4	Yes	?	No	?
5	Yes	-Between 3 and 5 years	Yes	20%
6	Yes for 5 years	-75% are in working condition -wide range of age	Yes, by weight	Less than 5%

7.5.3.6 OES Program

Every interviewee was aware of the new OES program. All but one of the companies which were still in business were going to be involved with the program in some way.

Companies 1, 3, 4, and 5 were all registered residential collection facilities. Company 6 was also a registered collection facility but only for industrial, commercial and institutional sector. Companies 4 and 6 are also registered EOL processors. Material collected at their facilities is sent to a consolidation center where it is weighted and split up before being sent back to be processed. All interviewees except for one believed the stewardship program would provide the necessary means to properly control IT-waste in Ontario. The interviewee from company 2 stated that the program was at least a start in the right direction but was not the solution. When asked if the $165 per tonne collection rate was fair, most said it was low, but it was better than nothing. Finally all were asked if there were any foreseeable issue with the new OES program. All indicated that they did not have the answer because they had to wait and see what happened once the program had started.

7.5.3.7 Education

There was complete agreement amongst all interviewees about the lack of public awareness of e-waste. The interviewee from company 4 believes that individuals have a general idea that this material is going to the landfill but are not really motivated to do anything about it because they have other worries. All stated better awareness and public education are needed about the dangers associated with improper management and disposal of IT-waste. Some expressed hope that the new OES program will bring some much needed information to the public.

7.5.3.8 Responsibility

Several questions examined different approaches to managing IT-waste and who should be held accountable. When asked who is responsible for IT-waste most said producers

and consumers. Producers created the problem in the first place by using hazardous materials. Consumers bought the products and should also make sure these products are properly managed at end of their lives. Interviewee 3 did not give an answer while interviewee 4 believed that consumers should be held solely responsible.

When asked what approach, regulatory versus voluntary, provides the best means to manage IT-waste there were a variety of answers. Companies 4 and 5 did not know how to answer that question. Company 2 believed voluntary was the best because if people truly care about the cause, they will do the right thing. Company 1 believed it should be mandatory because it would allow everyone to follow the same standards. Company 6 believed both voluntary and regulatory were the best approach –regulatory in the sense of placing a ban which does not allow IT-waste in the landfill; and voluntary in the sense of industry-created and approved standards. However all but one agreed that there should be government standards for the management of IT-waste in Ontario.

7.6 Summary

Several different methods were used to examine IT-waste management in the RMoW. Documentation provided essential information regarding the different aspects of waste management in the Region. Archival records identified e-waste collection trends. Observations illustrated the collection and disassembly procedures used. Interviews with different stakeholders provided information about the development of the e-waste ban, implementation of e-waste program, and the different disposal practices used for IT-waste management.

Chapter 8: The Ontario Experience with IT-waste: Results from the Surveys and Interviews

8.1 Background

The 2006 report from Waste Diversion Ontario identified 60 cities, counties, regional municipalities, towns, and townships around Ontario collecting WEEE (WDO, 2007b). These areas were all contacted either by phone or email to participate in a short survey or semi-structured interview. The purpose was to identify the benefits and limitations from what other areas around Ontario have done to manage residential IT-waste. Below are the results from the surveys and interview questions.

8.2 Results from Municipal Survey

Thirty-four of these areas answered the first survey question which asked whether their area recycled IT-waste. Three municipalities indicated they did not collect IT-waste anymore either because they were waiting for the OES program to be established or they could not find a contractor to manage IT-waste. Consequently, these 3 municipalities did not answer the rest of the survey questions. The other 31 areas had some type of program in place. The five follow-up questions examined convenience, cost, management, and promotion for each areas IT-waste recycling program. A list of the questions can be seen in Appendix F.

8.2.1 Convenience

The second question asked where and when residents can go to dispose of their IT-waste. The purpose of this question was twofold: first to determine the different types of

collection systems available; and second, to examine the amount of effort required by individuals to use the services offered. A drop-off approach was the only collection system indicated by all 31 interviewees. Drop-off means residents are required to bring their IT-waste to a designated location for disposal. Landfill and household hazardous waste centers and special collection day events were the only means identified for IT-waste drop-off. Eighteen of the municipalities used their landfills or household hazardous waste centers, 11 held special collection day events, and 2 indicated using both. Hours of operation for drop-off were dependent on the site. Only 3 municipalities had special hours for drop-off while the other sites indicated drop-off during normal hours of operation. With special collection days, areas differ regarding the number of events held yearly. The 11 municipalities holding special event days varied in when and how many events were held. For instance, one area had only 1 event day per year while another area scheduled 8 events per year.

8.2.2 Cost

The third question asked the costs to residents to recycle IT-waste. Twenty-three out of the 31 respondents did not charge a fee. Two interviewees stated that their special collection days were free to residents but landfill drop-off was not. The remaining 6 municipalities all had some sort of fee that was dependent on either the type or weight of product. For 3 areas, residents were charged $5 for computer monitors. Another municipality charged $5 for up to 20kg. In the last 2 municipalities, residents were charged either $.05 per pound or $.09 per pound of IT-waste disposal. All 25 areas that held special collection days provided free IT-waste recycling for its residents.

8.2.3 Management

Question four asked what happens to IT-waste that is left on the curb. The purpose of this question was to understand how IT-waste is managed when recycling services are not being utilized by the public (Figure 8.1). Four of the respondents did not know what happened to IT-waste left on side of the street. Nineteen indicated such waste would be left behind; two of these respondents stated that contractors would leave a sticker to inform resident that this waste was not acceptable in the regular waste stream. The other 17 respondents stated that they would simply leave the IT-waste alone. Two municipalities collected the IT waste and sent it to landfill.

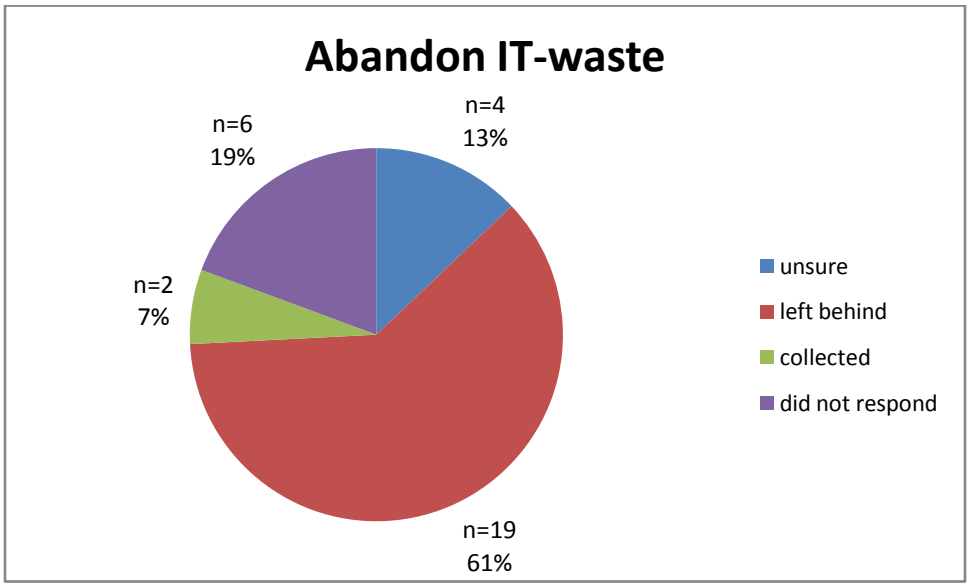

Figure 8.1 Outcomes for IT-waste left at curbside

8.2.4 Promotion

The last two questions of the survey examined program promotion. Question five asked what measures were in place to ensure residents were not throwing IT-waste into their regular garbage. Only 19 respondents answered this question (Figure 8.2). Thirteen (42%)

indicated taking action either in the form of implementing a curbside IT-waste ban (2), implementing a clear-bag policy (1), or providing educational material (10). With the ban option, one area has set a date for implementation while the other area is in the process of presenting this idea to council. One identified having a clear-bag policy. Clear bags allow workers to identify any material deemed inappropriate for landfill disposal and leave it behind. Ten interviewees indicated educating residents through brochures, newspaper ads, and webpages explaining the importance of recycling IT-waste. The other 6 municipalities took a do-nothing approach with 2 stating that they believed in the honour system that residents would utilize the services available to them. Twelve did not responded.

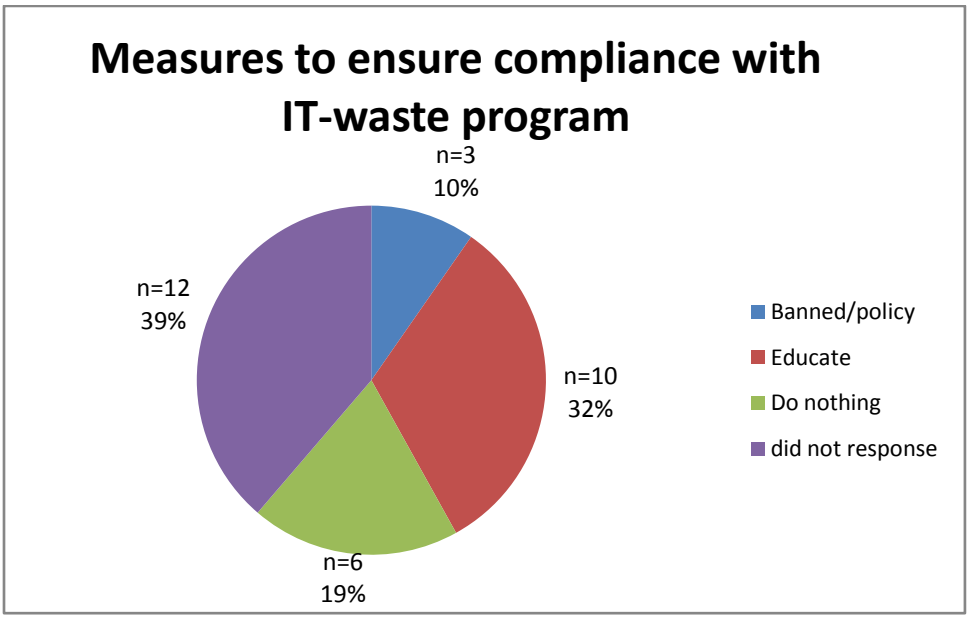

Figure 8.2 Breakdown of what different areas do to ensure compliance with their IT-waste program

The last question asked where further information can be found about their areas IT-waste recycling program. All 15 respondents said to check their municipal website for further information. Although 16 did not explicitly respond to the last question, 12 of these

municipalities indicated in previous questions, that further information could be found on their municipal website.

8.2.5 Webpage Analysis

As an additional check, a simple webpage analysis was conducted on all 15 areas who responded to the last question in the survey. Examining an area's websites was important because many areas rely on websites to communicate information to their residents. Criteria for analysis were based on a quick review of literature regarding webpage design and reputability (see table 8.1) Webpage design was selected because it looks at how well a website is able to convey information (US Department of Health and Human Services, 2006). Webpage reputability looks at quality of the information presented. These two categories were selected because the researcher felt that navigation ease and accuracy of information are two important characteristics residents require when obtaining information. The researcher created a checklist and used it to evaluate the 15 areas (see table 8.2). If the evaluation item was present on the website a + was given. If the evaluation item was not present a – was given.

Table 8.1 Criteria used for analyzing municipal webpage's

Webpage Design (U.S. Department of Health and Human Services, 2006)	**Webpage Reputability** (Beck, 1997)
Navigability – easy to move around the website and find what you are searching for	*Contact information* – where further information can be obtained
Communication- information is presented in a clear and concise manner	*Dates* – information is current
Graphics – labeled correctly and easy to read	*Content* –information is available and useful for their IT-waste program (when, where, and cost)

Table 8.2 Evaluation criteria which was used for webpage analysis

Evaluation Criteria for webpage analysis
1. Search for waste services on website was straightforward- residential services, waste management, or public works
2. E-waste information was clearly identified on website
3. Information was conveyed in layman terms
4. Graphics are easy to understand
5. Contact information is provided
6. Website is updated and information is correct
7. Information was informative about e-waste program
a. Disposal cost
b. Drop-off location
c. Days and times for drop-off
d. Materials collected
8. Informs what disposal method is used
9. Educates about the environmental and human health hazards associated was e-waste

The webpage analysis revealed some interesting findings. All 15 web pages were current and provided some type of contact information whether it was an email address or a phone number. However, webpage navigability (question 1) and communication (question 2) for 4 of the municipal webpage's were poor. E-waste or IT-waste was not given its own section, but was combined either with household hazards waste or recycling. Consequently, it took more searching to find information about an e-waste program. These same municipalities also had inadequate content information. There were no details about cost, location, and time for e-waste recycling (question 7a-d). This information is crucial because it lets residents know what to do with their unwanted equipment. For websites that were rated good (11), information was easy to identify and find because e-waste had its own category.

These websites received + on all the evaluation criteria except for question 9. All municipal websites except one did not provide any information about the environmental and human health hazards associated was e-waste. Ratings for all the different websites can be seen in Appendix G.

8.3 Regional Interviews

8.3.1 Background

There were 7 regional municipalities and 1 city selected for individual interviews. These 7 regional municipalities were chosen because they had a similar government arrangement as the Regional Municipality of Waterloo (RMoW) regarding decision-making (regional council decides) and waste management responsibilities (region is responsible for waste collection and programs). The city was chosen because it had already established a unique IT-waste program. Four of the 8 areas (Regional Municipality of Halton, Regional Municipality of Peel, city of Guelph, and anonymous) agreed to participate in an interview. Questions addressed how e-waste management was done in their regional municipality or city along with waste workers' personal feelings towards waste reduction initiatives. These sessions provided an opportunity to ask questions where information was unavailable – if they were considering enacting an IT-waste ban, if they shipped IT-waste overseas, how they tracked and monitored IT-waste, etc. A list of the questions can be seen in Appendix H.

8.3.2 Similarities

All interviewees said that their regional municipality and city had not enacted a curbside waste ban on IT-waste. One went on to further explain that individuals understand

the importance of recycling IT-waste and that a ban was not necessary. Everyone agreed that they have seen an increase in the amount of IT-waste sent for recycling in the past 5 years. This rise has influenced three of the areas to implement changes in their IT-waste collection, increasing the hours of drop-off, holding more event days and even building new facilities.

All the managers indicated that their facilities did not check IT products for functionality, age, maintenance, and material composition. Instead equipment is sent for complete destruction (equipment is broken down and separated into the different metals, plastics, and glass) before recycling occurs for a number of different reasons including:

- Privacy issues— residents are concerned that the content from their computer could become public knowledge if it is refurbished
- Limited resources— facilities do not have the money or time to go through each product
- Quantity— too many IT products to check
- Viability— even if products are still in working conditions it's not practical to refurbish because technology continues to evolve

Two out of the 4 stated that if residents wanted their products to be reused it was their own responsibility to drop it off at a reuse center. All agreed that residents are aware of the dangers associated with improper handling and disposal of IT-waste. Two went on to elaborate that although most of the public is unaware of the hazardous nature of the material, they understand the importance of recycling. Various advertisement methods (newspaper ads, telephone books, website, pamphlets, and radio commercials) have been used to promote each regional municipality and city's IT-waste program to explain the basic components of the program such as what materials are collected, location, cost, and time as well as the benefits of recycling this material. All agreed that this information does not educate residents about the hazardous nature of this waste and its impacts on human and

environmental health. Two respondents suggested that public behaviour proves residents understand the importance of recycling because they rarely see e-waste in their regular waste stream.

There was complete agreement with a number of other questions. All were aware of the Ontario WEEE stewardship program. All believed exporting to third-world countries is not an acceptable option for managing IT-waste. Everyone stated that landfilling or incineration was not considered an acceptable disposal option for handling IT-waste. Although different recycling companies were used, separation of monitors from other IT-equipment was identified as a common means of management. Finally all respondents indicated that they tracked where and what happens to IT-waste once it leaves their facilities.

8.3.3 Differences

When asked what other measures might prevent IT-waste from ending in landfill there were two groups of responses, promotion and convenience. Two believed earlier and more exposure to programs would lead to better IT-waste practices. The others suggested an increase in the number of events held a year, more depots with extended operating hours, and offer curbside collection. These actions would provide more convenience and hopefully lead to more participation with future IT-waste programs.

When asked if recycling facilities are inspected to ensure that materials sent there are being recycled, 3 out of the 4 said yes. All 3 indicated that somebody from their department goes to the recycling facility to inspect it periodically. Two of the interviewees went on to state that contracts are another important means to control where and what happens to IT-waste. Having clauses in the contracts outlining what is acceptable and what is not,

communicates to everyone involved what is expected. For example, one clause could prohibit companies from shipping waste overseas.

Managers were asked how much impact they thought the new OES WEEE stewardship program will have. There were a variety of answers from not sure to full pledge participation in the program. One of the respondents stated that council would have to decide if their regional municipality or city was going to use the resources offered by the program. The other three all indicated acceptance of the program stating that it would lead to better opportunities for cost and location. Two managers in particular seemed to imply that their regional municipality or city would wait until the WEEE program was implemented before any new services are created.

Several questions looked at different types of controls for managing IT-waste. The first question asked whether managers believe there is a need for government and industry guidelines to provide standards and targets when it comes to the management of IT-waste in Ontario. Three believed that both are necessary for the following reasons:

- Government guidelines provide universal rules that everyone has to adhere to
- It takes decision-making away from the waste managers and company and places responsibility on to the government who sets the standards for management.
- Industry guidelines play an important role because of product creation. Designing equipment with the environment in mind means less difficult at the end of the products life.

Guidelines provide clear directions, accountability and uniformity amongst all. When asked which approach, regulatory versus voluntary, provides the best means to manage IT-waste, one of the respondents was not sure while another believed both approaches work hand in hand. The respondent stated that a portion of the public will participate in a program

without being told. For those who do not want to participate, regulations force their hand more to comply. Two believed that regulation is the best route to take because it forces people to comply who otherwise would not.

Interviewees were asked what measures have been put in place locally to assist residents to dispose of their IT-waste. All mentioned promotion of their program and keeping the depots and special collection day events running. A follow-up question was asked regarding how convenient it is for residents to properly dispose of their unwanted IT-equipment when it comes to cost, location, and collection method. Table 8.3 below shows each manager's answer.

Table 8.3 Comparison of the different areas IT-waste programs

Region/city	**Cost**	**Time**	**Location**	**Collection method**	**Accessibility**
Area 1	Free up to 4 sets	Twice a week	Any of the 4 waste depots	Drop-off	Only by vehicle
Area 2	Free	3 events a year	waste facility	Drop-off	Only by vehicle
Area 3	8 cents a kilogram SED* -free	Open throughout the week	5 recycling centers Rotating special event days	Drop-off	Only by vehicle
Area 4	Free	1-SED 1-week long event	Waste management site	Drop-off	Only by vehicle

*SED- special event day

Finally, managers were asked what measures are in place locally to ensure that residents are not throwing away IT-equipment in the regular garbage. Two indicated that

nothing was in place. The other two said promotion of the program helped. An interesting comment made by one of the managers explained that his regional municipality or city mandated recycling for all residents. In order to ensure residents are complying with the mandate they use a three bag transparent colour system (clear—waste; green—organics; blue –recyclables) to see what is inside the bags. If the by-law officer sees contamination residents can be charged $110 fine, if it becomes a continuous problem. This type of program creates consequences for inappropriate behavior and has been successful in reducing contamination between recyclables, organics, and waste.

8.4 Summary

Surveys and interviews with different cities, counties, regional municipalities, towns, and townships provided insight into what other areas in Ontario have done to manage IT-waste.

Chapter 9: Discussion and Recommendations

This chapter is divided into two sections. The first section evaluates the Regional Municipality of Waterloo (RMoW) end of life (EOL) management of IT-waste based on the 15-point sustainable integrated waste management (IWM) criteria introduced in Chapter 5 section 5.4. Recommendations are provided to improve EOL management. The second section is a general evaluation of the entire Ontario information technology (IT) system (design, manufacturing, collection, and treatment). The purpose is to gain a holistic understanding to provide further recommendations in order to move towards a sustainable IT-waste management plan.

9.1 Evaluation of RMoW

The RMoW has taken a progressive stance when it comes to EOL management for IT-waste. Since 2005 the RMoW has implemented a curbside and landfill ban on electronic waste (e-waste), which includes IT-waste. This ban prohibits e-waste from being sent to the landfill. The Region has created an e-waste collection program and has established an e-waste directory. The program runs year round to provide convenience (see section 7.2.7). All of these initiatives have had positive environmental impacts. The RMoW e-waste collection totals per household are double those of three other regional municipalities (Halton, Niagara, and York), in spite of the fact that the RMoW imposes a fee structure while programs for 2 of the municipalities are free of charge (see section 7.3.1).

The Region's purchase of collapsible reusable skids (reusable plastic containers which are used for IT-waste packaging for recycling) shows long-term commitment to the e-waste program. This was further confirmed by Regional Municipal councillors who stated in

the interviews that the e-waste program will continue. The RMoW has made every effort to ensure that e-waste is managed appropriately. Costs have not influenced decision-making regarding selecting a processor (see section 7.5.1.9). All of these actions show commitment towards e-waste management, but do they mean that RMoW has a sustainable IWM plan for managing IT-waste? The researcher evaluated RMoW IT-waste management program by using the 15-point criteria developed from the principles of sustainability and waste management concepts (waste management hierarchy, cradle to cradle, and IWM). The findings are discussed below.

9.1.1.1 Knowledge and Education

RMoW residents must understand that there are many different routes EOL IT-waste can go depending on the quality of the equipment (see figure 4.2). At this time, residents have not been given adequate information or choices about alternative disposal routes other than recycling. Furthermore, residents have only been exposed to promotional information regarding the e-waste ban (what products, where to bring them, and how much it costs) (see section 7.5.1.5). All e-waste processors (see section 7.5.3.7) and Regional councillors (see section 7.5.2) interviewed, believe that the public is not fully informed about the dangers (human health and ecological impacts with improper disposal) associated with IT-waste and that further education is needed (see section 4.3.3).

Recommendation 1: The e-waste developer and educational coordinator should continue to allocate time and resources to educate the public. They should continue to provide general information about the e-waste program, in addition to offering new

information that highlights the environmental and human health dangers of improper management and the different disposal options available.

The RMoW appears to have the support (political, financial and staff) needed to improve their educational program. They have backing from Regional councillors who have stated that the ban is useful and will continue to be in place in the future (see section 7.5.2). Financially, the RMoW has shown that they are willing to spend money on their e-waste program (purchasing of collapsible reusable totes, hiring the most expensive processor) if the outcome will lead to improved environmental benefits (see sections 7.5.1.9 and 7.5.1.2). Finally, the Region has hired staff specifically responsible for developing and running promotional and educational programs (see section 7.2.8). Having a holistic understanding about the dangers associated with improper management and the different disposal options available will allow residents to make the most appropriate decisions when it come to EOL IT-waste management.

9.1.1.2 Behaviour

It appears that residents, excluding students, are using the e-waste program as indicated by the high collection totals and the minimal amount of abandoned IT-waste found along the roadside. Only university students have demonstrated poor behaviors with disposal of IT-waste as stated by both Regional waste workers (see section 7.5.1.5).

Recommendation 2: It may be useful to carry out a study identifying the reasons why the student population demonstrates poor IT-waste disposal behaviors.

Whether the student population is ignorant of the rules or just does not care, is unknown. What is evident is the collection method used by all processing companies and

municipalities. If individuals want to dispose of their IT-waste they must drop it off at a designated location. The RMoW landfill site is only accessible by vehicle (see section 7.4.1.1). Lack of transportation could be one reason for students poor disposal practices; another could be the disposal fee (see table 7.3). If students' leave their IT equipment on the curbside, clean-up is either done by the owners of student housing property or by the Region, which absorbs the disposal cost (see section 7.5.1.5). Although this researcher did not study the barriers for why student participation is poor, limited transportation and cost could be factors.

Recommendation 3: A partnership between the universities, RMoW, and OES should be created to provide drop-off locations at each university and college.

Recommendation 4: University and college students should be able to dispose of their IT-waste free of charge at their school.

The implementation of collection programs at universities and college campuses could lead to better behaviors because it not only provides convenience, but free IT-waste disposal. Increased proximity to where students congregate could improve student involvement. Research showed that in Belgium and Norway more drop-off locations led to higher levels of collection totals (see sections 5.3.1 and 5.3.3). Furthermore, if universities and colleges agreed to be collection sites, then the OES will provide all the necessary materials needed for running an e-waste collection program (see section 6.1). By partnering with the OES program, users can dispose of their e-waste free of charge. RMoW waste workers and university off-campus housing should still work together to inform students about the current e-waste ban and what resources are available. Creating a partnership

between these stakeholders could provide greater opportunities to spread the word about the e-waste ban and lead to a decrease in levels of abandon IT-waste.

9.1.1.3 Product Integrity

The RMoW does not examine the condition of incoming products. They do not have the labour or time to separate EOL products into either reuse or recycling categories (Regional waste management coordination, 2009). If residents want their products to be reused, it is their responsibility to find and send it to the appropriate facility. The Region does not follow the waste management hierarchy of first reuse and then recycle. Everything that is sent to the Region goes for recycling, whether it is in working condition or not (Regional waste management coordinator, 2009). The main reason stated for skipping the reuse stage is to protect the resident's privacy. All regional municipalities and city waste coordinators interviewed stated that consumers are apprehensive about their IT products being reused for fear that private information could be accessed (see sections 7.5.1.9 and 8.3.2).

Recommendation 5: Facilities collecting IT products for reuse should inform residents how information on their computer will be destroyed before it is sent for reuse.

All facilities that reuse products should indicate to their cliental how they destroy the information (zero or physical destruction). This is not something new that would require a great deal of time or investment. Rather all the processors interviewed either zeroed or physically destroy the hard-drive on equipment before it was sent for reuse or recycling (see section 7.5.3.3). The most amount of time would be spent creating and distributing information to the client about how private information is destroyed. Information can be

presented on posters at the facility's entrance, pamphlets at the desk, and on company websites which would not require a lot of time or money to accomplish.

Recommendation 6: It may be useful to investigate the amount of resources (cost, time, and space) needed to develop a collection program for reuse of IT equipment in the RMoW.

Recommendation 7: It may be useful to investigate the use of a checklist that residents could use to evaluate whether their product could be sent for reuse. This checklist could continue to be modified as the reuse market continues to change.

A designated reuse area at the Regional landfill site would allow residents the option of two disposal routes (reuse and recycle). Products sent for reuse would extend the life of the product and its component parts (refurbish and remanufacture) rather than breaking it down into lower quality recycled material (see section 4.4.3, 4.4.4 and 4.4.5). The RMoW e-waste program already has designated drop-off locations, hired staff, and experience with creating an e-waste recycling program, all of which could be used in the development of a reuse program. The real costs associated with a reuse program would be the time required to test the functionality of products (see section 7.5.1.9 and 8.3.2). However, to help alleviate this cost, residents could evaluate their own equipment using a general checklist created by the Region to evaluate the condition of a product. The item's condition will determine whether the product can go for reuse or recycling. The company hired to manage the RMoW reused IT equipment would be responsible for determining whether a product could be sent for reuse, refurbishing, or remanufacturing. Separating IT products into different disposal

routes (reuse, refurbish, remanufacture, recycle) does not eliminate the waste problem but prolongs virgin material from having to be extracted since material is already available.

9.1.1.4 Monitoring

Surface monitoring (visual look at the waste) takes place at the Waterloo and Cambridge transfer station. Employees watch for and remove any noticeable IT-waste that is mixed with regular garbage. There is no monitoring system in place for curbside collection. IT products could be placed in bags without garbage collectors realizing it (see section 7.5.1.6).

Recommendation 8: Implement a transparent bag system whereby garbage collectors are able to see the items being disposed.

If banned products were found in the transparent bag, a fine would be given. Although it might be difficult to see smaller e-waste products, it would be possible to identify large items such as printers, computers, and laptops. The clear bag system has been used and shown success in reducing curbside contamination as stated by one of the interviewees (see section 8.3.3). Therefore, this type of system would help monitor curbside collection and force accountability for inappropriate disposal actions. This recommendation would require cooperation and commitment from a number of stakeholders including: waste workers, public, and stores. Waste workers would have to spend the time developing the program and educating the public. Residents would have to purchase clear bags if they wanted their trash to be collected by the Region. Stores would have to sell garbage bags approved by the Region. Monitoring curbside collection prevents IT products from ending up in the landfill,

where it not only takes up space but could lead to heavy metals leaching into the surrounding area (Schmidt, 2002; Wong et al., 2007).

9.1.1.5 Stakeholder Responsibility

Regional councillors, regional waste management workers and residents all have a particular responsibility for the management of IT-waste in the RMoW. Each stakeholder knows his or her role with the management of IT-waste. Regional councillors implemented the ban to force changes in behaviors. Regional waste staff developed and now run the e-waste program. Most residents, excluding students, use the services provided. The current system appears to be running effectively since large amounts of IT-waste are being diverted away from the landfill and are being recycled as indicated by the collection totals (see section 7.3.1). From the evidence gathered, no further recommendations for stakeholder responsibility seem to be needed.

9.1.1.6 Convenience

The Region's e-waste program is open to the public most days except for holidays to provide convenience for anyone to drop-off their equipment. Individuals are required to drop-off their products either at the Waterloo or Cambridge transfer stations, which are only accessible by car (Waterloo Waste Management, 2004). It may be difficult for certain portions of the population (elderly, disabled, students, residents with no mode of personal transportation) to participate in the program. Furthermore, there are no drop-off centers in any of the townships and limited public transit services between the cities and their surrounding townships (see section 7.5.1.7).

Recommendation 9: Pick-up services should be provided for individuals who require assistance because of age or physical abilities.

The city of Toronto and Greater Sudbury already have a pick-up program to assist residents who are unable to drop-off toxic products themselves. Residents can call up the toxic taxi and workers will be dispatched to their home to pick-up toxic materials free of charge (Greater Sudbury, 2008). The Region could use the toxic taxi program as a model for developing their own volunteer program for housebound individuals. Residents of the RMoW could assist by establishing a volunteer group to collect IT-waste from the housebound portion of the population. Volunteers would also help save the Region time and money since they would not be responsible for its collection.

Recommendation 10: Multiple drop-off events should be held in central locations such as near the main bus station and at the universities.

Recommendation 11: Special collection days should be rotated between townships throughout the year to provide better convenience to the rural portions of the population.

Special collection days that are free of charge could exist, if the Region worked in conjunction with the OES program. The OES program would provide the following resources:

- $165 per tonne incentive for collecting, sorting, and packaging WEEE for transportation
- Free training material for staff
- Free promotional and educational material
- Free transportation to a consolidation center and processing center
- Free equipment support (reusable containers, pallets, shrink wrap)

The RMoW does not have to worry about whether the OES processors will be able to meet the Region's standards since one of the approved processors is who the Region already uses (SIMS). What the RMoW should be responsible for is identifying areas which are easily accessible to the public, large enough to hold event days, and free to use the space. Staff to assist with the collection is also needed. Convenience plays just as important role in waste management as diverting waste into different disposal options. Having a program but not making it convenient is like doing nothing at all.

9.1.1.7 Standards

The RMoW created an e-waste directory as a resource residents could use to identify alternative places to send their e-waste. A company can simply be added to this directory if it is an e-waste processor and wishes to be identified. Companies in the directory vary considerably, as was seen in the interviews with different e-waste processors. Some had a certification of approval while others did not. Some send their IT equipment to be reused overseas (see sections 7.5.3.1 and 7.5.3.2). By having this directory and not having controls in place to ensure consistency in management, the Region may be indirectly supporting inappropriate IT-waste management.

Recommendation 12: Companies listed in the directory should all follow the same standards (RMoW criteria, see section 7.9.1.2) to ensure products sent anywhere are being managed in a consistent manner.

Recommendation 13: It may be useful to develop a standardized form for evaluation of processing companies.

A regional waste worker should assess each company using a standardize form to ensure consistency in evaluation before a company is placed in the directory. This already happens to any processing company contracted by the OES program. Processing companies are evaluated and must follow specific management requirements. These requirements are in place to ensure consistency and care with human and environmental health when it comes to the handling, reusing, refurbishing, and recycling of materials (see section 6.2.4). Standards provide clear directions, accountability and uniformity amongst all companies to maintain a level of performance that is consistent no matter where a product goes.

9.1.1.8 Regulations and Enforcements

The Region has taken a proactive approach with the implementation of the *Landfill and Curbside Waste Collection of Electronic Waste Ban.* This ban is beneficial because it specifically prohibits disposal of e-waste in the landfill. Even with this ban in place it is not being followed by everyone e.g., the student population. The Region does not enforce the ban with penalties and fines for non-compliance. Rather, IT products found in front of a house are left behind while abandoned products (found in a field) are cleaned up by the Region (Regional waste management coordinator, 2009).

Recommendation 14: By-law officers should hand out penalties to any resident who is seen to improperly disposal of IT products.

Recommendation 15: If residents witness improper disposal they should be encouraged to report it.

Research has shown that most individuals who abandon products do so because the chance of getting caught and prosecuted is low and fines are small (New Brunswick Solid

Waste Association and Atlantic Coastal Action Program, 2006). This is true for the RMoW which has enacted an e-waste ban, but fails to enforce it. Both RMoW waste workers stated enforcement of regulations requires manpower and money (see section 7.5.1.8). However clean-up of IT-waste also costs the Region both time and money and it could lead to adverse environmental impacts, if the equipment is broken and exposed to the elements (see section 4.2.2). A pilot program carried out by the Iowa Department of Natural Resources (2006) found that catching illegal dumpers and imposing a fee is successful in deterring illegal dumping. To assist law enforcement officers, the Iowa Department of Natural Resources relied on residential assistance to report illegal dumping. Community watch service is not a police group because they do not have the power to enforce compliance. Rather a community watch group tries to improve the community by directing by-law officers to the perpetrator(s) to prevent further issues.

9.1.1.9 Affordability

Cost has not been a determining factor in the development of the program. In several cases the more expensive option has been selected, for example the e-waste processor used by the Region and the purchase of collapsible reusable skids. Both of these decisions looked at what was better for the environment (Regional waste management coordinator, 2009). The Regions e-waste program runs at a net loss because the fees charged do not cover the full cost of transportation, handling, and disposal (see section 7.5.1.9). However, the Region penalizes individuals with an increased disposal fee if they recycle more than 4 items at one time (table 7.3). This action may lead to some individuals keeping their IT in storage which can create a number of different problems (see section 4.4.1)

Recommendation 16: There should be no penalties on the amount of IT-waste a resident brings to be recycled at one time. A person who brings in one piece of equipment should pay $10 while a person who brings 6 pieces should pay $60.

The RMoW has imposed a fee for the recycling of residential IT-waste. However, with the introduction of the OES program, brand owners, first importers, retailers, and assemblers are required to pay fees for electrical and electronic equipment (EEE) sold in Ontario (OES, 2008a). These companies and their retail customers can decide whether the cost will be internalize (non-visible fee) or consumers will be charged an environmental visible handling fee at the point of purchase (OES, 2009). Either way any residents who recycle their e-waste at the RMoW will be paying double if they have purchased IT-equipment after April 1, 2009.

Recommendation 17: One provincial fee should be implemented upfront with the purchase of any electronic equipment to create consistency and eliminate paying double.

An up-front disposal fee has been used in countries such as Norway, Netherlands, and Switzerland to comply with the WEEE directive. Implementing an up-front fee at the point of purchase allows for all IT-waste to be recycled anywhere that collects IT-waste for free. Since a fee has already been collected at the point of purchase, if an IT manufacturer goes out of business the product can still be recycled later on (see sections 5.3.1, 5.3.2, and 5.3.5). Holding stakeholders accountable at the beginning of a products life ensures resources are available for management at the end of its life.

9.1.1.10 Collaboration and Participation

Before the RMoW e-waste program started, discussion took place between waste management staff, residents, and city councillors. Regional waste management staff provided information outlining the program and the potential benefits. Residents were allowed to voice their concerns and regional councillors evaluated all the information before rendering a decision (see sections 7.5.2). Since the implementation of the ban minimal changes have taken place. Only recently has discussion regarding e-waste management started again because of the new OES program. The RMoW has many decisions to make in the near future about what to do with its program. Both RMoW waste workers stated they hoped to keep the ban but phase out the e-waste program and let producers, distributors, and retailers take care of the problem (see section 7.5.1.7). The RMoW has decided not to become a registered collection facility because of a number of concerns it has with the OES program (see section 8.5.1.9).

Recommendation 18: Residents should have an internet forum where they can discuss the current e-waste program.

Recommendation 19: A panel discussion about the future of the Regions e-waste program should be open to all interested parties.

Recommendation 20: The OES and Region should work collaboratively with one another to satisfy both parties' interest to best manage EOL e-waste products for RMoW residents.

Regional waste managers should collect information from residents about their attitudes towards the current e-waste program as well as the new OES program. Obtaining

public opinion on these two programs will help to highlight areas where improvement is needed. When the OES program was being developed, a participatory approach was used (see section 6.1). This approach was used because it gave everyone in the province of Ontario the opportunity to be heard. The main communication methods the OES relied on were webcasts, workshops, discussion forums, and an e-mail account specifically dedicated to this topic (OES, 2008c). Holding workshops, creating an e-waste management forum, and establishing a toll free call line are all methods of communication that have worked in the past to get the public involved without requiring a great deal of resources. Collaboration and participation allows for greater understanding of the situation so improved management can take place now and in the future.

9.1.1.11 Reporting

The Region of Waterloo receives a certification of destruction report from their processor which identifies how many pounds and what percentages of products were able to be recycled after a load has been sent to them. It appears that the actual reports are not publicly accessible. However, the Region will sometimes provide statistics about how much e-waste was diverted from landfill and recycled. Collection totals can also be found on the Waste Diversion Ontario website. From the evidence gathered, no further recommendations for reporting seem to be needed.

9.1.1.12 Proximity

It is important that products be managed close to the source to prevent other environmental issues associated with transportation. Although the processor is located 88 kilometers away, which is farther than some other processors in the area, it were rated better

and more equipped to manage e-waste. Comparing how far away something is to the quality of management is all relative. It is difficult to determine where to draw the balance between performance and distance because each has their own environmental impacts. However, the RMoW is not shipping their waste overseas and the manufacturer is located relatively close. From the evidence gathered, no further recommendations for proximity seem to be needed.

9.1.2 Conclusion

As identified above, the RMoW has done much to ensure EOL IT products are sent for recycling. It has implemented a ban, created an e-waste collection program, purchased reusable skids, and has chosen an e-waste processor based on environmental performance rather than cost. The Region is on the right path towards achieving a sustainable IT-waste program, but there are areas where improvements are needed, as discussed above. The sustainable IWM criteria identified in chapter 5 were used as an assessment tool to evaluate the RMoW e-waste program. If all of these recommendations are adopted it may lead to a localized sustainable IWM plan for IT-waste management in the RMoW. The recommendations build on one another. If the Region does not show full commitment and only decides to use a selection of the recommendations they will not have the intended impact. For example if the transparency bag recommendation is not implemented, curbside monitoring of IT products cannot take place. Consequently, without using a transparent bag system, the potential for IT-waste to be discarded in the landfill is not only higher, but also is not a sustainable disposal approach. The RMoW has power to create positive change with EOL management if the above recommendations are implemented.

9.2 Evaluation of Ontario Management of IT-waste

The RMoW collection program is only one component in a much larger IT-waste management system. The Region only has control over EOL management of IT-waste. If a true sustainable IWM plan for IT-waste were to be created it must look at the entire IT system (design, manufacturing, collection, and treatment) and all the different stakeholders (manufacturers, government, resident, and waste processors) in order to identify where changes can be made. Discussed below is an examination of the entire Ontario IT system and the findings.

9.2.1.1 Design and Manufacturing (Knowledge and Behavior)

Manufacturers are continuously redesigning IT products to improve memory, speed, looks, weight, and capabilities (Envirosris, 2000). IT products are designed to be made quickly and cheaply so more products can be sold. This philosophy has become the norm for manufacturers. It has led to decreased lifespan and increased in the amount of IT products sent for disposal each year, as indicated by all municipal waste managers interviewed (Babu et al., 2007; Lee et al., 2007; Saphores et al., 2006). There are no financial incentives for manufacturers to change product design. There are no rules forbidding the use of hazardous materials. Products are not designed for easy disassembly and modification. Finally, manufacturers do not feel the full-cost their products have on the ecological system (Grossman, 2006). As such, products are designed for built-in obsolescence. What this illustrates is that IT products are not designed with the environment in mind.

Recommendation 21: Federal legislation should be created to prohibit certain materials from being used in electronic products.

Recommendation 22: Green design should be promoted through decreasing fees within the OES program or provision of tax breaks by the provincial government.

Recommendation 23: Upgrading products should be easier so IT products can continue to be used (i.e., they should have a longer lifespan).

These recommendations are not impossible to achieve. Other areas around the world have already implemented similar programs as suggested above. For example, in the European Union (EU), the Restriction of Hazardous Substances (RoHS) Directive, requires manufacturers to eliminate certain hazards (lead, cadmium, mercury, hexavalent chromium, and brominated flame retardants) if they wish to sell their products in the European Market (Oh and Thompson, 2006). In the United States, the Federal government has implemented tax credits to promote green design. The energy efficient appliance tax credit allows manufacturers of clothes washers, dishwashers, refrigerators and freezers to receive a tax credit for each unit, up to 75 million. Tax credits vary per model depending on its energy and water efficiency ratings (DSIRE, 2008). With both programs, manufacturers have been able to improve product design in order to reduce the impact a product has on the environment.

What is required is more planning before these recommendations can be implemented. Manufacturers have to invest the time and money into developing products that are nonhazardous, easy to upgrade, and durable. The Federal and Provincial government needs the time and workforce to create and pass legislation. All of these recommendations take preventative measures to eliminate problems at the beginning stages of product production in order to prevent issues later on with EOL disposal.

9.2.1.2 Collection (Convenience)

Increases in the number of IT products discarded have led to the creation of different avenues for collection. In 2006, 60 municipalities voluntarily implemented their own IT-waste collection initiative for their residents. All municipalities surveyed and interviewed used a drop-off approach for collection (see section 8.2.1 and 8.3.2). Residents are required to bring their equipment to a designated location which is usually only accessible by car (see table 8.3). This is also the same collection approach used in the new OES program. Consequently, this commonly used approach makes it more difficult for certain portions of the population to participate. Elderly and disabled individuals might not have the strength or endurance to move their IT products, while individuals with no mode of private transportation may be less inclined to spend the time and effort to send their product(s) for reuse or recycling. In addition to recommendation 9 stated above there are several other recommendations (see section 9.1.1.6).

Recommendation 24: Special drop-off events should be held in central locations such as near main bus stations or government buildings where these areas can easily be reached by all. This way all affected parties still have an opportunity to dispose of their IT products properly.

Recommendation 25: More drop-off centers should be created for greater residential convenience.

Countries such as Belgium and Norway have thousands of drop-off locations for their residents and these countries are often smaller than Ontario (see sections 5.3.1 and 5.3.3). Retailers, volunteer organizations, and waste management facilities all have an opportunity

to collect e-waste for recycling. However, it is up to each stakeholder if it wants to use the resources (money, materials, and staff) OES has to offer.

9.2.1.3 Processing Route (Product Integrity)

If residents do choose to use an e-waste service or the OES program instead of sending IT-waste to the landfill, there are only two streams: reuse (refurbish and remanufacture) and recycle. Products are reused only if there is a market (in some cases sending them to developing countries) otherwise they will go for recycling. Products sent for recycling are disassembled and sent to downstream processors for recycling. Although both of these options are better than landfilling, there are still issues. Sending reused products to developing countries does not manage the problem but transfers responsibility. Products that are sent for recycling are down-cycled into lower grade materials (see section 4.4.6). EOL disposal options have been the only area in the IT lifecycle where attention and resources have been given to IT-waste management. There are no incentives for manufacturers to change product design which has led to the current problem.

Recommendation 26: It may be useful for manufacturers to move towards an eco-effective business design approach (see section 2.3.2).

What this means is consumers are no longer buying products to own but rather a service. Once the service is over the product can be taken back by the manufacturer where it can be modified and reintroduced back into the market. As such, the manufacturer has to change from designing equipment with built-in obsolescence to designing equipment to be disassembled and used to create new products (McDonough and Braungart, 2002).

Consumers of electronic equipment and manufacturers will be the two parties most responsible if this recommendation is to happen.

9.2.1.4 Treatment (Standards)

The new OES program has set standards for reuse and recycling companies OES chooses to use. However, there are no national standards when it comes to the implementation of an independent municipal IT-waste collection program. Each municipality decides what type of collection program it wants and where it will be sent for recycling (OES, 2008c). For example, the RMoW selected its e-waste recycler based on a set of criteria it created to evaluate environmental performance. For other municipalities, selection may be solely based on cost or convenience. Although municipalities are sending their IT-waste for recycling there are varying degrees in how it is being managed, as was revealed in the interviews with different e-waste processors. Recycling of electronic products is largely unregulated in Canada (Kang and Schorming, 2005). This lack of regulation is why some companies are able to: have no Certification of Approval, send products overseas for reuse, have incomplete records, and not perform downstream auditing on outside companies (see sections, 7.5.3.2 and 7.5.3.5). Although municipalities think they are sending their collected IT-waste to be recycled responsibly, this might not always be the case. It is important that adequate attention and thought be given when evaluating recycling and reuse companies.

Recommendation 27: If municipalities want to have their own e-waste collection program, a standard set of criteria should be used to ensure consistency in recycling performance across processors. The criteria set should include:

- ISO 14001 registration

- 98% diversion rate from landfill
- Provisions of proof of destruction (destruction certification)
- Downstream auditing and monitoring of third-party users
- Up to date approved provincial regulation (Certification of Approval)
- Proof of insurance
- Adherence to employee health and safety laws
- No shipment of IT-waste to developing countries

Three out of the 4 waste managers interviewed believed guidelines are necessary to provide standards for IT-waste management (see section 8.3.3). Using the criteria set should create standards within this industry by forcing companies to comply if they want to stay in business. Standards provide clear directions, accountability and uniformity amongst all. The provincial government should work with the OES program to provide consistency in recycling and reuse standards for all e-waste processors in Ontario.

9.2.1.5 Collaboration and Participation

There is rarely any communication amongst and between different manufactures and EOL processors. As such there is no consistency between competing manufacturers and their products. As stated by one processor: "Some companies chose to use Philips screw heads while others use Robertsons." If there was open communication and collaboration among industries it could potentially lead to more efficient and effective product design (see section 7.5.3.4).

Recommendation 28: It may be beneficial for the manufacturing industry and EOL processors to collaboratively work with one another to improve the design of products.

Recommendation 29: It may be beneficial to create uniformity among all manufacturers when it comes to the types of screws, power connectors, battery, and input and output connectors used and their placement in products.

Creating some uniformity in IT design could allow for easier substitution of parts and disassembly. For example, if a computer battery died the consumer could pick-up a generic battery instead of having no choice and being force to buy a new battery from the manufacturer. Furthermore, it could also create a new reuse market since component parts would be identical to one another. For instance, if every IT manufacturer used the same type of screws they could be collected and sent back to the manufacturer where they could be used in new products (see section 7.5.3.4). The screw would not be recycled and downgraded into a lower quality product but stay in its original material state where it could continue to be used (see section 2.3.2).

9.2.1.6 Regulation and Enforcement

The OES program was created to help combat discrepancies between municipal programs. It is a province wide program where residents can go to drop-off their e-waste at designated collection sites free of charge. All collected products are sent to an approved e-waste processing facilities for management (OES, 2008c). The program tries to provide uniformity across the province when it comes to EOL e-waste management. It is not a perfect system as discussed in chapter 6. It does not ban e-waste from Ontario landfills and incinerators, but rather encourages citizens to use the services available. Consequently, in most places in Ontario residents are still allowed to place their IT equipment in their regular garbage because there are no bans stating otherwise.

Recommendation 30: A provincial ban should be placed on all IT-waste to ensure products are not sent to the landfill or incinerator.

It may force some residents to use an e-waste service who would not have otherwise done so. This recommendation requires cooperation between the provincial and municipal governments. The province should be responsible for developing and implementing the ban. Municipalities should be responsible for monitoring and enforcing the ban.

There are already regulations in place for processors to prevent inappropriate behaviors, but minimal enforcement measures taken to ensure that they are being upheld (Ministry of the Environment, 2007). For example, 4 out of the 7 e-waste processors interviewed did not have their Certification of Approval even though they transported and stored waste. There are three main reasons why this certification system appears to have failed. First, multiple interpretation means unclear information is being presented. Each company gave a different explanation as to why they believed they were excluded from certification. Second there are no penalties to force companies to register. Third the government rarely checks to see if companies are registering as indicated by one of the interviewees (see section 7.5.3.2). One informant stated that in the 6 years since getting his Certification of Approval no one from the Ministry of the Environment has visited the facility. Furthermore, there are loopholes in international documents. The *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal* has been signed and ratified by Canada. However, the amendment regarding the exportation of hazardous materials to developing countries has yet to be ratified and as such, is not legally

binding (Whitney and Webb, 2008). It is for these reasons that companies are allowed to send products to developing countries to be reused.

Recommendation 31: Stronger and clearer governmental guidelines should be in place to prevent misunderstanding and provide accountability and uniformity amongst all affected parties.

Recommendation 32: Watchdog groups should be created to help governments monitor these facilities to ensure rules are being followed.

Recommendation 33: Existing regulations should be better enforced through a penalty system.

Three out of the 4 waste managers interviewed believed government regulations are necessary (see section 8.3.3) Regulations force consistency and compliance but are only as good as how well they are being monitored and enforced. With the WEEE Directive, national governments are required to develop and hold down penalties for non-compliance with the Directive. For example in the Netherlands penalties can vary between fines (25,000 to 100,000 guilders), imprisonment (up to 2 years), closure of business (up to 1 year), and compensation for damages (Sino-Swiss E-waste initiative, 2009). The OES program has also implemented a penalty system for non-compliance with the Act (see section 6.1). The federal and provincial governments need to create regulations which can be easily understood and enforced. In order for these recommendations to succeed it will cost the government time, money, and labour. If the province charging fines for non-compliance they could use this money for monitoring and enforcement.

9.2.1.7 Education

Residents are not educated about the environmental and human health dangers associated with IT-waste (see sections 8.2.5, 8.3.2, and 7.5.3.7). A webpage analysis further proved this point with only 1 webpage identifying issues with improper management. Rather residents are informed about the basic components of the program such as what materials are collected, location, cost, and time (see section 8.3.2).

Recommendation 34: Residents should be educated on the dangers of e-waste so they understand the importance of sending EOL products for reuse or recycling.

Websites are used by many areas to communicate information to their residents, but are not being utilized to their full potential. Websites could be one approach to educate residents about the environmental and human health hazards associated with improper IT-waste disposal. Characteristics identified under design and reputability would have to be incorporated into a website if it was to have any impact on residential education (see section 8.2.5). Furthermore, the provincial government along with the OES program could develop and provide information for the public from the money collected through manufacturer's fees.

9.2.1.8 Reporting and Monitoring

With the new OES program all collectors, consolidators, and processors are required to track, monitor and report to the OES where and what happens to products sent for reuse and recycling (OES, 2008c). However, with a municipal e-waste collection program it is somewhat different. Each municipality decides who to use and if they want to publish e-waste collection totals in Waste Diversion Ontario Municipal Datacall. In 2006, 16 of the 60

municipalities who indicated they collected e-waste never provided collection totals (WDO, 2007b). Furthermore municipalities can decide if they want to monitor their processor. Three out of the 4 regional municipalities and city managers interviewed stated somebody from their department visits the processing facility periodically to check how IT-waste is being recycled (see section 8.3.3). Since each municipality decides how to run its waste management program, there is variations in reporting and monitoring between different municipalities (see section 4.4.8)

Recommendation 35: Independent municipal programs should report yearly collection totals to Waste Diversion Ontario Municipal Datacall.

Recommendation 36: Every independent municipal program should monitor where and what is happening to collected IT-waste.

Not reporting and monitoring this information provides incomplete data for Ontario e-waste diversion totals. It does not provide accountability for processors on where and how IT-waste is being managed. Consequently, products could be shipped overseas. The EU WEEE directive believes reporting and monitoring is imperative and requires each government to submit a written report to the EU Council every 3 years. Each company that runs a country's collection program is responsible for monitoring. The purpose is to examine a country's WEEE program performance when it comes to meeting the collection target, recovery and recycling rates, and where products are sent (see section 5.2.1). Municipal governments and processors have to work with one another when it comes to monitoring and reporting how products are being managed.

9.2.1.9 Proximity

Studies have shown that developing countries' rudimentary recycling and improper safety equipment have led to long-term health effects for individuals living in these areas (Huo, et al., 2007; Wong, 2007). Even with international legislation in place to prevent hazardous waste from being shipped overseas, they are not being followed (see section 4.4.2). IT products still continue to be shipped overseas because of the cheap labour cost and minimal environmental standards. E-waste handlers are willing to pay the additional cost associated with transit, because low paid workers wages offset the cost allowing more profit to be made (UNEP, 2005). With the OES program, processors are not allowed to ship to developing countries but can send their e-waste to OECD countries as long as they are able to meet or surpasses the Ontario requirements for environmental, health and safety standards (see 6.2.4). In addition to recommendation 33 stated above there is another recommendation for proximity (see section 9.2.1.6).

Recommendation 37: IT-waste generated in Ontario should be managed in Canada.

Sending IT-waste to developing countries is not managing the IT-waste situation but rather transferring the problem to other areas that are not equipped to handle the waste appropriately. Furthermore, not managing the problem at the source requires more fossil fuel which results in more emissions being released. Sending IT-waste outside of the country is taking business and materials away from Canadian processors and recycling companies. The Federal government, e-waste handlers, processors, and downstream recyclers, and OES will need to work with each other to create partnerships for managing all aspects of IT-waste in Canada.

9.2.1.10 Affordability

A UN study found that the manufacturing of a computer takes 530 pounds of fossil fuels, 48 pounds of chemicals, and 1.5 tonnes of water (UNEP, 2005). Consumers are not paying the full environmental costs associated with manufacturing a computer. In fact, equipment has gotten cheaper. Rapid technological succession has created a decreased lifespan and an increased disposal rate for electronic products. It has also led to working equipment being discarded before its time (Babu et al., 2007; Lee et al., 2007; Saphores et al., 2006).

Recommendation 38: It may be useful to include the social, environmental, economical cost from manufacturing to disposal in the price of a product.

If consumers were required to pay the full cost of the product they may continue to use the equipment until it is no longer usable. This recommendation would require time and cooperation from all countries and manufacturers. An international regulation signed by all countries would have to be created which would force all manufacturers to include the social, environmental, and economical costs associated with the manufacturing of the product. If it was not a universal rule it would allow some manufacturers to not charge this fee, which would make their products considerably cheaper. This is what has already taken place with e-waste recycling in developing countries. Because there are no universal regulations and developing countries have weaker labour and environmental and human health laws, recycling e-waste in developing countries is considerably cheaper than developed countries (see section 4.4.2). Cost of products would have to be similar for this recommendation to have the desired affects of reduced consumption and increase product lifespan.

9.2.1.11 Changes in Attitude

The public continues to be bombarded with advertisements explaining why they should purchase the newest IT products. Many individuals have bought into this message as indicated by the fact that: the first life of a computer has moved from 4.5 years down to 2. Furthermore, 50% of discarded IT products are still in working conditions (Babu et al., 2007; Envirosris, 2000; Kang and Schoeming, 2005). Because IT products have become so affordable consumers continue to purchase new models. A change in attitude needs to take place.

Recommendation 39: Residents should be exposed to messages that explain alternative means to extend the life of a product such as upgrading the system or buying a service rather than the product.

Manufacturers and the media should change their advertising tactics away from consumption driven ads to ones that educate consumers about what alternative options are available to extend the life of electronic equipment.

9.2.2 Conclusion

There are no rules governing what is taking place with IT-waste management in Ontario. There is limited communication, collaboration, and cooperation between the different stakeholders. IT-waste management is about short term eco-efficient solutions (3R's) rather than long-term eco-effective solutions (zero waste design). There is no accountability required by stakeholders; therefore inappropriate actions are taking place. There are limited restrictions on what chemicals manufacturers can use in Ontario. Residents can send their IT-waste out with the regular trash in some locations. Finally, waste processors

decide where to send waste (developed vs. developing countries) and how they want to process IT products. There are no provincial bans prohibiting any of these actions. Each of these factors along with the others listed above has led to the current unsustainable management approach for IT-waste in Ontario. The entire system of IT management has to be reworked in order for a sustainable IWM plan for IT management to occur. For this to happen, commitment, communication, and collaboration from all actors within the system must take place in order to promote the implementation of different recommendations. The sustainable IWM criteria provide general guidelines to consider for designing a sustainable management plan for IT-waste. The set of criteria takes a holistic approach by considering both the short and long term impacts with managing IT-waste.

The Ministry of the Environment has started to recognize the importance of proper management though the implementation of a number of policy initiatives for different problematic waste, including WEEE. The Waste Diversion Act (WDA) forces brand owners to take responsibility for their product once no longer wanted. It pushes accountability further back in the system so those who created the problem take responsibility for it. The goal is to take a proactive approach to prevent problems at EOL management. At this point, the OES program has established a number of initiatives to allow for easier diversion of WEEE. It provides an avenue for residents to drop-off their IT-waste free of charge. It has established more drop-off locations. It has created greater public awareness about IT-waste issue. It will take a variety of different e-waste products in the future. It has implemented standards when it comes to IT-waste recycling (OES, 2008a). The provincial program has given individuals a choice to direct their IT-waste towards reuse or recycling. Although the Minister of the

Environment has set up the OES program to help promote better management of e-waste, there are no bans prohibiting this waste from ending up in the landfill. Consequently, the program is only as good as the proportion of people who choose to participate in it. The OES program is a start in the right direction, but it takes an eco-efficient approach to reduce, not eliminate, the waste problem. The recommendations above take an eco-efficient approach to dealing with the problem currently and eco-effective approach to managing the problem in the future. Similar recommendations could be applied, potentially, to any other type of e-waste also.

Chapter 10: Conclusion

The research question for this thesis addressed understanding how an integrated waste management (IWM) plan might be developed in the Regional Municipality of Waterloo (RMoW) that best manages information technology (IT) waste. To answer this research question several sub-questions were posed.

First, what set of criteria constitutes a sustainable IWM plan for managing IT-waste? In order for this set of criteria to be developed, the researcher took the broad categories found under sustainability and directly applied them to waste management hierarchy, cradle to cradle, and IWM concepts. Aspects from the European case analysis and the literature review were also incorporated so that the criteria are case specific for the management of IT products (see Chapter 5, 5.4).

Second, what can be done to improve Waterloo's management of IT-waste based on lessons learned from other initiatives? An analysis on 5 European countries identified ideas of what other countries have done. The main findings were implementing fees at the point of purchase, provided free collection at disposal, and increasing the number of drop-off locations led to greater participation with e-waste collection.

Third, how does Waterloo's current management of IT-waste measure up to the developed criteria? Interviews with RMoW councilors, RMoW waste management workers, e-waste processing companies as well as an observation at the Regional e-waste collection site identified where successes and failures lay within the current IT-waste management system. Recommendations were developed to improve RMoW management of IT-waste through the criteria (see Chapter 9, 9.1).

The final question was can this plan be carried over into other Ontario municipalities? Although only 1 case study was performed information collected the OES program analysis, surveys, and interviewees all seem to indicate similar issues. Therefore, many of the recommendations suggested for RMoW could also be implemented in other Ontario municipalities (see figure 10.1) Compiling all the information gathered from the 4 questions led to the conclusion that the RMoW is headed in the right direction for managing EOL IT-waste but that there are more actions that can be taken to sustainably manage IT-waste in the future.

If a truly sustainable IWM plan is to be created for IT-waste management, the entire IT system must be examined in order to try to eliminate waste from the beginning. An examination of the entire IT-waste system was completed using the sustainable IWM criteria indirectly to identify where Ontario has failed in IT-waste management. RMoW alone does not have control in what happens to the rest of the system. However, with the support of other local governments, the provincial government, and residents; positive changes can occur in order to move towards a sustainable IWM plan for managing IT-waste and other forms of e-waste. Table 10.1 identifies how the researcher placed each recommendation into three categories including location, product, and timeframe. Location indicates whether the recommendation is context specific for the RMoW or it can be applied to municipalities throughout Ontario. Product identifies whether the recommendation applies only to IT-waste or other forms of e-waste (telecommunication equipment, audio/visual equipment, tools, and toys). Finally, timeframe suggests whether the recommendation can be implemented immediately or in the future. Immediate suggest that it does not require a great deal of effort

and that the resources (time, money, and manpower) are available. Future means more effort and planning will be required before the recommendation can be implemented.

Table 10.1 List of the recommendations and how they rate with respects to location, product, and timeframe

Recommendation	Location	Product	Timeframe
1.The e-waste developer and educational coordinator should continue to allocate time and resources to educate the public. They should continue to provide general information about the e-waste program, in addition to offering new information that highlights the environmental and human health dangers of improper management and the different disposal options available.	RMoW	E-waste	Immediate
2. It may be useful to carry out a study identifying the reasons why the student population demonstrates poor IT-waste disposal behaviors.	RMoW	E-waste	Future
3. A partnership between the Universities, RMoW, and OES should be created to provide drop-off locations at each university and college.	RMoW	E-waste	Future
4. University and college students should be able to dispose of their EOL IT-waste free of charge at their school.	RMoW	E-waste	Future
5. Facilities collecting IT products for reuse should inform residents how information on their computer will be destroyed before it is sent for reuse.	All municipalities	IT-waste	Immediate
6. It may be useful to investigate the amount of resources (cost, time, and space) needed to develop a collection program for reuse of IT equipment in the RMoW.	All municipalities	E-waste	Future
7. It may be useful to investigate the use of a checklist residents could use to evaluate whether their product could be sent for reuse. This checklist could continue to be modified as the reuse market continues to change.	All municipalities	E-waste	Future

8. Implement a transparent bag system whereby garbage collectors are able to see the items being disposed.	All municipalities	E-waste	Future
9. Pick-up services should be provided for individuals who require assistance because of age or physical abilities.	All municipalities	E-waste	Future
10. Multiple drop-off events should be held in central locations such as near the main bus station and at the universities.	All municipalities	E-waste	Future
11. Special collection days should be rotated between townships throughout the year to provide better convenience to the rural portions of the population.	RMoW	E-waste	Future
12. Companies listed in the directory should all follow the same standards (RMoW criteria, see section 7.9.1.2)	All municipalities	E-waste	Future
13. It may be useful to develop a standardized form for evaluation of processing companies.	All municipalities	E-waste	Future
14. By-law officers should hand out penalties to any resident who is seen to improperly disposal of IT products.	All municipalities	E-waste	Future
15. If residents witness improper disposal they should be encouraged to report it.	All municipalities	E-waste	Immediate
16. There should be no penalties on the amount of IT-waste a resident brings to be recycled at one time. A person who brings in one piece of equipment should pay $10 while a person who brings 6 pieces should pay $60.	RMoW	E-waste	Immediate
17. One provincial fee should be implemented upfront with the purchase of any electronic equipment to create consistency and eliminate paying double.	All municipalities	E-waste	Future
18. Residents should have an internet forum where they can discuss the current e-waste program.	All municipalities	E-waste	Immediate

19. A panel discussion about the future of the Regions e-waste program should be open to all interested parties.	RMoW	E-waste	Immediate
20. The OES and Region should work collaboratively with one another to satisfy both parties' interest to best manage EOL e-waste products for RMoW residents.	RMoW	E-waste	Immediate
21. Federal legislation should be created to prohibit certain materials from being used in electronic products.	N/A	E-waste	Future
22. Green design should be promoted through decreasing fees within the OES program or provision of tax breaks by the provincial government.	N/A	E-waste	Future
23. Upgrading products should be easier so IT products can continue to be used (i.e., they should have a longer lifespan).	N/A	E-waste	Future
24. Special drop-off events should be held in central locations such as near main bus stations or government buildings where these areas can easily be reached by all.	All municipalities	E-waste	Future
25. More drop-off centers should be created for greater residential convenience.	All municipalities	E-waste	Future
26. It may be useful for manufacturers to move towards an eco-effective business design approach	N/A	E-waste	Future
27. If municipalities want to have their own e-waste collection program, a standard set of criteria should be used to ensure consistency in recycling performance across programs.	All municipalities	E-waste	Future
28. It may be beneficial for the manufacturing industry and EOL processors to collaboratively work with one another to improve the design of products.	N/A	E-waste	Immediate

29. It may be beneficial to create uniformity among all manufacturers when it comes to the types of screws, power connectors, battery, and input and output connectors used and their placement in products.	N/A	IT-waste	Future
30. A provincial ban should be placed on all IT-waste to ensure products are not sent to the landfill or incinerator.	N/A	E-waste	Future
31. Stronger and clearer governmental guidelines should be in place to prevent misunderstanding and provide accountability and uniformity amongst all affected parties.	N/A	E-waste	Future
32. Watchdog groups should be created to help governments monitor these facilities to ensure rules are being followed	All municipalities	E-waste	Future
33. Existing regulations should be better enforced through a penalty system.	N/A	E-waste	Immediate
34. Residents should be educated on the dangers of e-waste so they understand the importance of sending EOL products for reuse or recycling.	All municipalities	E-waste	Immediate
35. Independent municipal programs should report yearly collection totals to Waste Diversion Ontario Municipal Datacall.	All municipalities	E-waste	Immediate
36. Every independent municipal program should monitor where and what is happening to collected IT-waste.	All municipalities	E-waste	Future
37. IT-waste generated in Ontario should be managed in Canada.	All municipalities	E-waste	Future
38. It may be useful to include the social, environmental, economical cost from manufacturing to disposal in the price of a product.	N/A	E-waste	Future
39. Residents should be exposed to messages that explain alternative means to extend the life of a product such as upgrading the system or buying a	All municipalities	E-waste	Immediate

service rather than the product.

10.1 Contributions

10.1.1 Theoretical

The relationship between IWM and sustainability remains ambiguous. The sustainability framework emphasizes the importance of moving towards sustainable decision-making through using a multi-perspective approach. The IWM concepts have been used previously to develop waste diversion programs. They help to minimize IT-waste problem but do not eliminate them. The cradle to cradle concept eradicates waste altogether by looking at products and designing them for zero waste. This research integrated these concepts together through the use of a case approach in order to generate a conceptual framework for a sustainable IWM approach for IT-waste management. The contribution was the clarification of a sustainable IWM relationship. Finally this research provided an additional waste management case study for the literature.

10.1.2 Applied

No universal standards have been adopted for Ontario municipalities for the management of IT-waste. The findings from this research contributed to development of a feasible IWM plan for RMoW and Ontario for IT-waste management based on set of sustainable IWM criteria developed specifically for IT-waste. It also offered a critique of the OES WEEE program plan.

10.2 Limitations

A number of limitations presented themselves while the research was carried out. First, only e-waste collection totals were presented each year and not IT-waste totals. The researcher could only make estimations of what IT-waste totals could have been but it was not a true representation of what the actual figure may have been. Second, interviews were not held with individuals working for the OES because they did not have the time to be interviewed. The OES program was being implemented during the same time as data collection was taking place. Third, multiple attempts were made to interview individuals in the Ministry of the Environment, but no one ever responded for an interview. Not interviewing these two stakeholders did limit the research. There were no provincial or manufacturer opinions with regards to IT-waste management. However, the OES report did provide insight about the roles and responsibility manufacturer have created for themselves, with respects IT-waste management in the province. Fourth, only 7 e-waste processors agreed to be interviewed out of 20 which is only a 35% response rate. Fifth only 1 observation took place at the RMoW collection site an e-waste processing facility. The reason why other e-waste processors were not observed was due to a number of reasons including distance, scheduling difficulties, and no public access. Sixth there was a low response rate with questions 4 and 5 in the survey. One possible explanation could be individuals answering this question were not very familiar with their areas e-waste program. Finally only one case study was performed because of time constraints. Although there were low response rates and few observation sessions, the data collected from the different

methods provided the same types of conclusions. Even though this case study has limited applicability, the information that it provides is unique and has never been presented before.

10.3 Evaluation of Criteria

This researcher tried to take a holistic approach to understand and improve IT-waste management. Multiple methods were used to collect information in order to evaluate the case study and OES program using the 15 point sustainable IWM criteria. The criteria used for this thesis proved to be useful but two changes could be made to improve the criteria based on the researcher's experience. First, collaboration and participation should be combined into one criterion since they are mutually exclusive to one another. Stakeholders cannot collaborate with one another if there is no participation and vice verses. Second, commitment should be added as a criterion since all stakeholders should be on the same page when it comes to IT-waste management. Future researchers should consider these changes if they want to use this criteria to evaluate other problematic e-waste.

10.4 Future Direction for Research

The current study was an exploratory study and it enabled the identification of other issues that merit examination. Some future directions for this research are provided below:

- Identify whether residents are either unaware or misinformed about the e-waste situation and what form of educational material is needed to get the greatest amount of commitment
- Examine why the student population demonstrates poor EOL IT-waste disposal behaviors
- Examine cost required to enforce the e-waste ban versus clean-up of abandon e-waste with no form of enforcement
- More case studies should be done on other types of e-waste such as televisions and cell phones since these products have changed considerably in the last few years

- A review of the OES program should be done in 5 years to see how well it was able to meet all the objectives it has set out to do
- Determine how much of an impact the RoHS Directive has had if any in North America and whether a program like that should be implemented here
- Look at the feasibility of implementing a transparent bag system in the Region of Waterloo – to allow easy in curbside monitoring
- Determine which form of recycling is better: shredding entire products vs. manually dissembling products into different material components
- Determine how feasible these recommendations are able to be implemented

10.5 Conclusion

The RMoW has taken many strides to promote residential recycling of IT-waste. They are one of the first areas to have implemented an e-waste ban. They have developed an e-waste directory to give residents choices when it comes to price and location for disposal. They collect e-waste all year round. Finally, the RMoW rigorously screens their e-waste processor based on environmental performance. All of these initiatives have led to high IT-waste collection totals in this area. The RMoW is on the way to building a sustainable IWM program for IT-waste, but there are more actions which could be taken. The 4 most important actions include:

- Build in a reuse program to extend the life of resources found within IT product as an alternative disposal option to recycling
- Standardize all processors used by the RMoW on the RMoW e-waste directory (see section 7.9.3.2)
- Better education to all RMoW residents regarding environmental and human health impacts
- Improve drop-off convenience to increase reuse and recycling

The sustainable management of IT-waste cannot be undertaken by the Region alone. The RMoW only has control over EOL management. There are only several steps (reuse and recycle) that can be taken to improve EOL IT-waste management, but not eliminate the

problem. A sustainable IWM plan is about understanding the entire situation in order to make the best choices possible. Changes in manufacturing design and consumer behavior needs to happen. Manufacturers have to start designing IT products that do not generate waste but rather can continuously be used in the same state. Consumers have to refuse to buy new IT equipment just because they do not have the latest and greatest. For a sustainable IWM plan to be created and to succeed, requires commitment, communication, and collaboration by all stakeholders.

Commitment for a common purpose will lead to success if all stakeholders are devoted to the same cause. Currently, each manufacturer, government, residents, and processors independently decides how to handle IT equipment. Consequently, manufacturers build products that are cheap and toxic; municipalities decide whether or not they want to participate (independent or partnership with OES program) in IT collection; residents chose where (reuse, recycle, or landfill) to dispose of unwanted IT-waste; and e-waste processors decide where to send (developed or developing countries) products for reuse and recycling. Commitment towards a sustainable IWM plan for IT-waste requires all stakeholders to be dedicated to the same cause which requires communicate and collaborate.

Communication allows for the exchange of information in order to create understanding. Knowing the audience you want to reach (who), the type of information you want to present (what), how to present it (how), is vital for building a sustainable IWM plan. RMoW stated the basic components of their e-waste program, but fail to educate the public about the importance of proper disposal. Communicating the right kind of information can lead to knowledge and changes in behavior. Communication also allows for collaboration

between stakeholders which can offer new insight through the exchange of ideas. However, the research showed a lack of communication and collaboration between:

- Manufacturers and e-waste processors— has made the disassembly of IT-equipment inefficient
- Manufacturers and manufacturers—creating products for built in obsolescence
- Manufacturers and government— allowing products to be made with hazardous materials
- OES council and RMoW— has led to non participation in the OES program for fear of the unknown

Changes need to be made with the current management IT system. If the factors mentioned above are considered and addressed when forming and implementing a sustainable IWM plan, there is potential for a successful program. If lack of attention is paid to any of these factors it could potentially jeopardize the success of creating sustainable IWM plan for IT-waste in the future.

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Appendices

Appendix A: Categories of products classified as e-waste

Large and small household appliances

Information technology

Telecommunication equipment

Audio/visual equipment

Lighting equipment

Tools

Toys

Medical equipment

Monitor and control instruments

Automatic dispenser

Appendix B: List of Products Classified as IT-waste

Information Technology Equipment:

CD-ROM drive

Computer disk drive

Computer mouse

Computer keyboard

Computer terminals

Microcomputer

Minicomputer

Monitor (CRT)

Monitor (LCD)

Monitor (Plasma)

Personal Computer (Desktop)

Personal Computer (Laptop)

Personal Computer (Notebook)

Personal Computer (Notepad)

Printer

Appendix C: Regional Municipality of Waterloo Waste Management Interview Questions

1. What factors (environment, economic, convenience, public opinion) are considered when deciding what disposal options to use when it comes to the management of IT-waste?

2. Which of these factors have more of an influence on decision-making and why?

3. Have you seen an increase in the amount of IT-waste discarded in the past 5 years? If yes, do you think rising amounts of IT-waste will have an impact on how you will deal with IT-waste in the future?

4. What approach, regulatory versus voluntary, provides the best means to manage IT-waste and why?

5. Is there a current system in place to track and monitor IT-waste once it leaves your facility? If yes, what is it?

6. In 2005 Waterloo enacted E-04-092: *Landfill and curbside waste collection of electronic waste ban.* What were the driving factors which led to this implementation despite the fact that it is not regulated province wide?

7. Are you formula of the new Ontario WEEE stewardship program?

8. Are you going to use the resources available from the Ontario WEEE stewardship program?

9. In your opinion, do municipalities with no IT-waste ban in effect have an impact on those that do have IT program in place? If yes, what is the extent of the impact?

10. What are the current or past public education/awareness programs that have informed the public about the banned?

11. How much of an influence do you think programs has on individual's behavior when it comes to disposing of IT-waste?

12. How could you research populations that are not participating in the program such as students who continue to leave?

13. What measures are in place locally to ensure that residents are not throwing away IT-equipment in with their regular garbage?

14. Who should take responsibility when it comes to IT -waste?

15. Can you comment on the condition and age of the IT waste collected in the Region?

16. Are IT products separated into different disposal options depending on the condition of the items? If not why? If yes, what disposal options?

17. What Regional resources (time, money, space, etc…) have been utilized to maintain and enforce the IT-ban?

18. Do you think that there is a need for government guidelines to provide standards and targets when it comes to the management of IT-waste in Ontario? What about industry guidelines?

19. Do you believe that manufacturers are aware of the impacts their products have on the environment? Please explain

20. Why are Waterloo and Cambridge the only waste facilities where residents can drop-off their IT-waste? How convenient is it for individuals who live in one of the surrounding townships and who depend on public transit?

21. Since the ban has come into effect has there been an increase in abandon IT-waste? What happens to it?

Region Waste Management Coordinator

1. What happens to IT-waste found around apartment buildings?

2. Is there a problem with students leaving IT waste curbside, who cleans it up?

3. Where do you send IT-waste? Where is that located?

4. What enforcements measures are in place to ensure the ban is being followed by the public?

5. Are there areas in the program where improvements could be made?

6. What happens to the money collected from IT-waste drop-off?

Manager of Operations

1. How do resident feel about paying a fee?

2. Do residents from the townships complain about the distance travel to dispose of IT-waste?

Appendix D: Regional Municipal Councillors Interview Questions

1. In 2005 waterloo enacted E-04-092: *landfill and curbside waste collection of electronic waste ban.* What were the driving factors which led to this implementation despite the fact that it is not regulated province wide?

2. Do you believe that the public is fully informed about the dangers associated with E-waste? If so how much of an influence do you think it has on their behavior when it comes to disposing of IT-waste? If not, do you think that additional information is required? Why?

3. Is the E-waste ban useful for the community or not? Please explain…..

4. Does the IT-waste ban take money away from council's budget? If so, why do you still decide to have in place?

5. Do you think that there is a need for provincial government guidelines to provide standards when it comes to the management of E-waste in Ontario? What about industry guidelines?

6. How much influence does the regional council have with respect to the development and implementation of the ban?

7. Do you believe the ban will continue to be in place in the future?

Appendix E: E-waste Processor Interview Questions

1. What type of e-waste products do you take?

2. Do you accept residential IT-waste? If no, would you take municipally collected residential IT-waste?

3. Are IT products separated into different disposal options depending on the condition of the items? If not why? If yes what disposal options?

4. Do you re-use or refurbish IT-waste? If yes, what happens to equipment that does not go of reuse?

5. How do you ensure sensitive information found on IT equipment is destroyed?

6. Are individuals hesitant about having their computers re-used because of the chance the information might still be on there?

7. Municipal waste manager I have interviewed have all indicated that it's too hard to separate reusable equipment from recyclable because of the amount time and resources it will take. How are you able to do this?

8. Do you recycle IT-waste at your facility or are you a broker who collected e-waste and sends it out to be recycled?

9. What percentage of the product gets recycled?

10. How is it recycled?

11. Do you outsource some of the recycling to other companies? If yes, how do you ensure that the companies are recycling the products you send them?

12. Are you ISO 14001 registered? Do you have your certification of approval from the Environmental protection Agency to handle this waste?

13. As design of IT products continues to change, how much of an impact does design have on its disposal?

14. What approach, regulatory versus voluntary, provides the best means to manage IT-waste and why?

15. Do you keep records of sources and end destination of IT-waste that comes into your business?

16. Are you formula of the new Ontario WEEE stewardship program?

17. Are you going to be one of the registered facilities where products will be sent for recycling? Are you going to be a consolidation center?

18. Do you think this stewardship program will provide the necessary means to properly control IT-waste in Ontario?

19. Are there any foreseeable issues you may have with the new OES program?

20. Do you believe that the public is fully informed about the dangers associated with IT-waste? If so how much of an influence do you think it has on their behavior when it comes to disposing of IT-waste? If not, do you think that additional information is required? Why?

21. Who should take responsibility when it comes to IT -waste?

22. Can you comment on the condition and age of the IT waste you collect?

23. Do you charge a fee? If so how much and what does that include? If not how is your service financed?

24. How much of your business come from residents living in areas where there is an IT-waste ban?

25. Do you think that there is a need for government guidelines to provide standards and targets when it comes to the management of IT-waste in Ontario? What about industry guidelines?

Appendix F: Survey Questions to Municipal Waste Managers

1. Do you recycle information technology waste including computers, related computer components, monitors, and printers?

If you answer yes, please answer the following questions:

2. When and where can residents go to drop-off their information technology waste?

3. Is there a fee for residents to recycle their information technology? How much?

4. What happens to information technology waste that is left on the curb?

5. What measures are in place locally to ensure residents are not throwing information technology in with their regular garbage?

6. Where could I find further material about your program?

Appendix G: Criteria and Evaluation of Website Analysis

dfgdfg **Evaluation Criteria for webpage analysis**
Q1. Search for waste services on website was straightforward- residential services, waste management, or public works
Q2. E-waste information was clearly identified on website
Q3. Information was conveyed in layman terms
Q4. Graphics are easy to understand
Q5. Contact information is provided
Q6. Website is updated and information is correct
Q7. Information was informative about e-waste program
a. disposal cost
b. drop-off location
c. Days and times for drop-off
d. Materials collected
Q8. Informs what disposal method is used
Q9. Educates about the environmental and human health hazards associated was e-waste

	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9	Area 10	Area 11	Area 12	Area 13	Area 14	Area 15
Q1	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Q2	-	+	+	+	+	+	-	+	+	-	-	+	+	+	+
Q3	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Q4	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Q5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Q6	-	+	+	+	+	+	-	+	+	-	-	+	+	+	+
Q7															
A	-	+	+	+	+	+	-	+	+	-	-	+	+	+	+
B	-	+	+	+	+	+	-	+	+	-	-	+	+	+	+
C	-	+	+	+	+	+	-	+	+	-	-	+	+	+	+
D	-	+	+	+	+	+	-	+	+	-	-	+	+	+	+
Q8	-	+	+	+	+	+	-	+	+	-	-	+	+	+	+
Q9	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-

Appendix H: Regional Municipal and City Waste Management Interview Questions

1. Has your municipality considered enacting a waste ban on IT-waste? Are you considering doing something in the future?

2. In your opinion do you feel a ban is not necessary?

3. What other measures might prevent IT waste from ending up in the landfill?

4. Do you feel that residents are aware of the dangers associated with improper handling and disposal of IT-waste?

5. Have you seen an increase in the amount of IT-waste discarded in the past 5 years? If yes, do you think rising amounts of IT-waste will have an impact on how you will deal with IT-waste in the future?

6. What happens to IT products once it has been drop-off?

7. Could you estimate how much of a factor the below mentioned variable play in determine the route for IT-waste disposal: functionality, age, maintenance, and material composition?

8. How often do products assigned for reuse get exported to developing nations?

9. Is exporting to third world countries considered an acceptable option of managing IT-equipment?

10. Is there a current system in place to track and monitor IT-waste once it leaves your facility? If yes, what is it?

11. Are recycling facilities inspected to ensure that materials sent there are being recycled properly?

12. Is landfilling considered an acceptable disposal option for handling IT-waste? How about incineration?

13. Are you familiar with the new Ontario WEEE stewardship program?

14. Are you going to use the resources available from the Ontario WEEE stewardship program?

15. Do you think that there is a need for government guidelines to provide standards and targets when it comes to the management of IT-waste in Ontario? What about industry guidelines?

16. What approach, regulatory versus voluntary, provides the best means to manage IT-waste and why?

17. Do you believe that manufacturers are aware of the impacts their products have on the environment? Please explain

18. What measures have been put in place locally to assist residents to dispose of their IT-waste?

19. How convenient is it for residence to properly dispose of their unwanted IT-equipment when it comes to price and location?

20. What measures are in place locally to ensure that residents are not throwing away IT-equipment in with their regular garbage?

21. Finally would you be willing to provide me with business numbers for anyone else who you think is knowledgeable when it comes to the management of IT-waste?