Waste Management Practices: Literature Review

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ABBREVIATIONS

C&D: Construction and demolition

C2C: Cradle-to-cradle

C2G: Cradle-to-grave

EPR: Extended producer responsibility

ICI: Institutional, commercial and industrial

IE: Industrial ecology

IWM: Integrated waste management

LCA: Life cycle assessment (Analysis)

MRF: Materials recovery facility

MSW: Municipal solid waste

NGO: Non-governmental organization

OCC: Old corrugated cardboard

OM&R: Operation, maintenance and repair

PAYT: Pay as you throw

SWM: Sustainable waste management

TABLE OF CONTENTS

SUMMARY **1**
INTRODUCTION **2**
Purpose 2
Methods 2
WASTE CHARACTERISTICS **3**
Waste Streams 3
The ICI Sector 4
GUIDING FRAMEWORKS **6**
Integrated Waste Management 6
Waste Diversion & Waste Minimization 8
KEY CONCEPTS **11**
Zero Waste 11
Cradle-to-Cradle / Cradle-to-Grave 12
Eco-Efficiency 13
Industrial Ecology 14
Summary 16
GOALS, OBJECTIVES, INDICATORS, TARGETS, STRATEGIES **17**
STRATEGIES **20**
Command and Control 20
Extended Producer Responsibility *20*
Federal Law and Policy *21*
Provincial Law and Policy *22*
Municipal Law and Policy *24*
Waste Management Regions *24*
Enforcement and Compliance *25*
Economic Instruments and Institutional Innovation 27
Incentives and Policies *27*
Use-Based Waste Management Fees - Pay As You Throw *28*
(Environmental) Supply Chain Management *29*
Education and Monitoring 29
Waste Characterization Studies *29*
Behavioural *30*
OPERATIONAL LOGISTICS **31**
Preliminary Considerations 31
Collection, Storage, and Processing 31
Equipment 32
Collection Equipment *32*
Processing Equipment *35*
Hazardous Waste Equipment 36
Waste Service Providers 37
Signage and Labelling 38
Costs 39
Human Resources 39
Evaluation 40

REFERENCES **41**
APPENDICES **48**
Appendix A - Resources 48
Appendix B - Definitions 50
Appendix C - Materials Banned From Disposal Sites in Nova Scotia 52
Appendix D - Different Tiers of Waste Management Costs 53
Appendix E - Stakeholders typically involved with a waste management strategy 54

LIST OF TABLES

Table 1: Waste streams classified by source (adopted from Tchobanoglous & Kreith, 2002) 5

Table 2: The five categories of industrial symbiosis 15

Table 3: Summary of key goals, objectives, indicators, targets and strategies outlined in various waste management frameworks 18

Table 4: Policy based incentives which may be implemented to increase recycling rates (Barlaz, Loughlin, & Lee, 2003; Loughlin & Barlaz, 2006) 27

Table 5: Commonly used collection equipment (Adopted from CCME, 1996, p. 33 33

Table 6: Commonly used processing equipment (Adopted from CCME, 1996; UC Davis, n.d.) 35

Table 7: Stakeholders typically involved with a waste management strategy 54

Table 8: The different tiers of costs associated with waste management (N. P. Cheremisinoff, 2003) 53

LIST OF FIGURES

Figure 1: Waste management hierarchy with waste reduction at the top, and landfilling and combustion on the bottom as the least favourable options (CIELP, 2008) 9

Figure 2: Cradle-to-cradle systems strive to reuse products and recycle waste products into base materials for new products (El-Haggar, 2007) 12

Figure 3: Nova Scotia's waste governance structure (Wagner & Arnold, 2008) 23

Figure 4: Nova Scotia's waste management regions (Source: RRFB.com) 25

Figure 5: Key legislation and events pertaining to waste management in Nova Scotia (Gary Davidson, 2011) 26

Figure 6: The colour coding, signage, and bin openings recommended by the RRFB (RRFB, n.d. b) 38

Figure 7: Signage and colour coding recommended by HRM (HRM, 2010) 38

SUMMARY

Managing waste can be challenging for industrial, commercial and institutional (ICI) sectors. Organizations must deal with a wide variety of materials, large volumes of waste, and behaviours of many customers, visitors, and/or students from within and outside of the province. There is no one action that will best fit the needs of all ICI sector organizations. However, a strategic solid waste resource management planning approach will help to define solid solutions. Integrated waste resource management planning enables organizations to create a comprehensive strategy that can remain flexible in light of changing economic, social, material (products and packaging) and environmental conditions.

In many cases, the most efficient and cost effective way to manage waste is to not have to deal with it at all; therefore waste diversion and waste minimization are often a primary focus for most integrated waste management plans. Specific goals and targets are defined in a plan. In many jurisdictions, the ICI sector must follow prescribed federal, provincial and municipal goals and targets as identified in acts, regulations, and bylaws.

Waste management is largely regulated by legislation and policy implemented at the municipal level, but there are significant provincial regulations that may come into play. In some instances federal regulations may also be relevant, particularly if dealing with hazardous substances or shipping waste across provincial boundaries.

Operational logistics play an important role in designing a waste management plan. The equipment, human resources, and budgetary requirements of the plan must all be considered in the design process as well as how the plan will be implemented, monitored and reviewed. Most organizations will require some services provided by commercial waste/recycling/composting service providers. With proper research, the contractual relationship with waste service providers can be negotiated to ensure that the contract provisions will allow for the successful implementation of the waste management strategy.

Before a comprehensive plan can be developed, a general knowledge of the waste composition and volume is required. This information is typically obtained by conducting waste characterization studies, or waste audits. In the beginning, waste audit information is essential to logistical planning. After implementation, waste audits are useful for measuring the success and progress of the plan and to identify areas which require review

INTRODUCTION

Purpose

The purpose of this literature review is to gain an understanding of waste management planning concepts, frameworks, strategies, and components that are current and emerging in the field. A particular focus is given to literature which pertains to the management of municipal solid waste (MSW) and construction and demolition (C&D) waste with a greater emphasis placed on information useful to organizations in the industrial, commercial and institutional (ICI) sector. The crucial elements of a comprehensive waste management plan are examined in detail. Specific information is given on the characteristics of MSW, existing frameworks, emerging trends, and important considerations. The literature review findings will be used in the development of an ICI waste management best practices guide for Nova Scotia. The literature review findings will aim to answer the following questions:

- What components are essential in a comprehensive waste management plan?
- What types of considerations should a NS ICI sector organization contemplate in developing a waste management plan?
- What is the range of options that exists in forming a waste management plan?

Methods

The literature review focuses on surveying information pertaining to existing waste management methodologies, policies, and research relevant to the ICI sector in Nova Scotia. Information was sourced from peer-reviewed academic literature, grey literature, publicly available waste management plans, and through consultation with waste management professionals. Literature pertaining to C&D and municipal solid waste minimization, auditing and management were searched for through online journal databases, particularly Web of Science, and Science Direct. Legislation pertaining to waste management in Nova Scotia, and in Canada, was also researched using the Canlii database. Additional information was obtained from grey literature and textbooks pertaining to waste management topics.

After conducting preliminary research, prevalent references of select sources were identified and scanned for additional relevant articles. Research was also expanded to include literature pertaining to recycling, composting, education, and case studies. Input from a sub-committee comprised of various waste management professionals identified areas requiring further research.

Wastewater, bio-solids, and hazardous wastes (as defined by the Canadian *Transportation of Dangerous Goods Act)* were not focused on in this literature review. Hazardous wastes are briefly discussed, but they typically require specialized management which lies outside of the scope of this literature review.

The literature review targets ICI sector organizations in Nova Scotia and thus information sources most directly related to the target audience were preferred. Newer sources were sourced; however, no cut-off date was implemented to restrict older material from being examined.

WASTE CHARACTERISTICS

A common misconception is that environmental protection and sustainable initiatives must come at the expense of economic development (El-Haggar, 2007). This is particularly true for managing wastes, a process which depletes natural resources and pollutes the environment if not done correctly. Proper waste management can be costly in terms of time and resources and so it is important to understand what options exist for managing waste in an effective, safe and sustainable manner (El-Haggar, 2007). This is particularly true for organizations which fall into the institutional, commercial and industrial (ICI) sector.

Waste Streams

Municipal solid wastes (MSW) is often described as the waste that is produced from residential and industrial (non-process wastes), commercial and institutional sources with the exception of hazardous and universal wastes, construction and demolition wastes, and liquid wastes (water, wastewater, industrial processes) (Tchobanoglous & Kreith, 2002).

In Nova Scotia, MSW is defined through the *Solid Waste-Resource Management Regulations* (1996) which state that MSW

> "..includes garbage, refuse, sludge, rubbish, tailings, debris, litter and other discarded materials resulting from residential, commercial, institutional and industrial activities which are commonly accepted at a municipal solid waste management facility, but excludes wastes from industrial activities regulated by an approval issued under the Nova Scotia *Environment Act"* (*SWRMR,* 1996).

Materials which are organic or recyclable are excluded from this definition, and so MSW in Nova Scotia is significantly different from that in many other jurisdictions. This definition of MSW works together with a legislated landfill ban which prohibits certain materials from landfill (Appendix C) to ensure that only certain materials are entering landfills. Banned materials cannot be disposed of and are processed through alternative methods (*SWRM,* 1996); typically recycling, reuse, or composting. The designation of materials into specific categories such as organics, recyclables, and garbage can differ by region, therefore organizations must ensure that waste is separated according to local area by-laws.

Construction and demolition (C&D) waste consists of materials which are normally produced as a result of construction, demolition, or renovation projects and can be a significant source of waste for all organizations in the ICI sector. According to the Nova Scotia *Solid Waste-Resource Management Regulations* (1996), C&D waste/debris "includes, but is not limited to, soil, asphalt, brick, mortar, drywall, plaster, cellulose, fibreglass fibres, gyproc, lumber, wood, asphalt shingles, and metals" .

Hazardous wastes are substances which are potentially hazardous to human health and/or the environment. As such, they typically require special disposal techniques to eliminate or reduce the hazards they pose (Meakin, 1992). Hazardous wastes are handled differently across different provinces;

however, many provinces, including Nova Scotia, have adopted the federal *Transportation of Dangerous Goods Regulations* to manage hazardous wastes. Hazardous wastes are typically classified by product type; however, it is important to consider that material properties and concentrations can impact the dangers and risks posed by certain materials (N. P. Cheremisinoff & P. N. Cheremisinoff, 1995). Knowledge of the properties of certain materials and products is essential, but information on impurities, trace materials, and intermediate by-products may also be needed since they can be potentially hazardous in certain quantities or forms.

Universal waste can be defined in a number of different ways. The United States Environmental Protection Agency (USEPA) defines universal waste as a set of hazardous materials that is generated in a wide variety of settings, by a vast community, which is present in significant volumes in nonhazardous waste systems (USEPA, 2005). The USEPA restricts the definition to four classes of materials: batteries, mercury-containing equipment, pesticides, and lamps. In California, legislation defines universal waste as hazardous wastes which are generated by households and businesses (CDTSC, 2010) that contain mercury, lead, cadmium, copper and other substances which are hazardous to human and environmental health (CDTSC, 2007). In California, there are seven designated types of universal waste: electronic devices, batteries, electric lamps, mercury-containing equipment, CRTs, CRT glass, and non-empty aerosol cans (CDTSC, 2010). Guidelines and regulations governing the handling and processing of universal waste are less stringent than hazardous waste regulations, thus allowing the hazards of universal waste to be recognized while allowing for greater flexibility in processing and treatment than with hazardous wastes (CDTSC, 2007; 2010; 2008; USEPA, 2005). Universal waste can differ by region, but will generally possess certain characteristics such as:

- posing certain environmental or health risks rendering it unsuitable for processing and disposal through regular municipal solid waste streams;
- posing lower risks than designated hazardous wastes;
- being generated by a wide variety of people, businesses, and settings;
  (CDTSC, 2007; 2008; 2010; USEPA, 2005)

The Universal waste definition is not commonly used in Canada to date; however, provides a logical way of grouping related material. Many products in this category would typically be consumer based household hazardous waste as opposed to hazardous waste as described under the Transportation of Dangerous Goods.

The ICI Sector

Organizations from all areas within the ICI sector are required to manage traditional solid waste, residential waste, and that which is not typically produced in residential settings (Table 1). This causes significant differences and presents unique challenges in waste management within the ICI sector versus municipal level solid waste management (El-Haggar, 2007; Tchobanoglous & Kreith, 2002). With municipal wastes, general characteristics can be common across various regions. The ICI sector however, produces a broad range of potential waste streams, including municipal and industrial solid

wastes, clinical wastes, construction and demolition wastes, hazardous wastes, and universal wastes which differ widely between organizations and can make comparisons difficult (El-Haggar, 2007; Woodard & Curran Inc., 2006). Commercial and institutional firms typically produce waste as a result of conducting trade and business (Smith & Scott, 2005), whereas the waste streams of industrial firms (manufacturing, repair, production) are typically characterized as liquid wastes, solid wastes, or air pollutants with each typically being managed and regulated differently (Woodard & Curran Inc., 2006). Industrial settings also produce MSW. Aside from dealing with highly varying waste streams, there is also the issue that many firms place a high value on company privacy and may not share information willingly (Ehrenfeld & Gertler, 1997).

Table 1: Waste streams classified by source (adopted from Tchobanoglous & Kreith, 2002)

Source	Facilities, activities, or locations where wastes are generated	Types of solid wastes
Residential	Single-family and multifamily dwellings; low-,medium, and high-density apartments. Can be included in IC&I sector	Food wastes, paper, cardboard, plastics, textiles, yard wastes, wood, ashes, street leaves, special wastes (including bulky items, consumer electronics, white goods, universal waste) and household hazardous waste.
Commercial	Stores, restaurants, markets, office buildings, hotels, motels, print shops, service stations, auto repair shops.	Paper, cardboard, plastics, wood, food wastes, glass, metal wastes, ashes, special wastes, hazardous wastes
Institutional	Schools, universities, hospitals, prisons, governmental centers	Same as commercial, plus biomedical
Industrial (non-process wastes)	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition	Same as commercial
Municipal Solid waste	All of the preceding	All of the preceding
Construction and Demolition	New construction sites, road repair, renovation sites, razing of buildings, broken pavement	Wood, steel, concrete, asphalt paving, asphalt roofing, gypsum board, rocks and soils.
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, power plants, demolition	Same as commercial, plus industrial process wastes, scrap materials
Agricultural	Field and row crops, orchards, vineyards, dairies, feedlots, farms	Spoiled food, agricultural waste, hazardous waste

GUIDING FRAMEWORKS

There is a growing concern of the impacts of product production and associated waste materials. With increasing support for improving the economic, environmental and social impacts of our actions material efficiency and waste management have been a primary focus of much research. In the USA, it is estimated that approximately 6% of all raw materials used end up as product, while only 1% ends up as durable products and the rest ends up as waste (Seadon, 2006). Although the differences in waste management strategies and definitions of waste are significantly different between countries, waste management remains to be a prominent issue with common methods of achieving certain goals and objectives (Sakai et al., 1996).

Integrated Waste Management

Waste management methods cannot be uniform across regions and sectors because individual waste management methods cannot deal with all potential waste materials in a sustainable manner (Staniškis, 2005). Conditions vary; therefore, procedures must also vary accordingly to ensure that these conditions can be successfully met. Waste management systems must remain flexible in light of changing economic, environmental and social conditions (McDougall et al., 2001; Scharfe, 2010). In most cases, waste management is carried out by a number of processes, many of which are closely interrelated; therefore it is logical to design holistic waste management systems, rather than alternative and competing options (Staniškis, 2005).

A variety of approaches have been developed to tackle waste issues. A well designed framework can help managers address waste management issues in a cost-effective and timely manner. It can spur the improvements of existing plans or aid in the design of new ones (USEPA, 1995).

A waste management framework provides:

- *Flexibility* to frame and analyze quantitative and qualitative information across different scales
- *Structure* to clearly identify key goals and values
- *Logic* to consider the potential probability and consequences related to a particular option
- *Communicability* to clearly communicate key ideas to key stakeholders (Owen, 2003).

Integrated waste management (IWM) has emerged as a holistic approach to managing waste by combining and applying a range of suitable techniques, technologies and management programs to achieve specific objectives and goals (McDougall et al., 2001; Tchobanoglous & Kreith, 2002). The concept of IWM arose out of recognition that waste management systems are comprised of several interconnected systems and functions, and has come to be known as “a framework of reference for designing and implementing new waste management systems and for analysing and optimising existing systems” (UNEP, 1996). Just as there is no individual waste management method which is suitable for processing all waste in a sustainable manner, there is no perfect IWM system (McDougall et al., 2001). Individual IWM systems will vary across regions and organizations, but there are some key features which characterize IWM:

- employing a holistic approach which assesses the overall environmental burdens and economic costs of the system, allowing for strategic planning;
- using a range of collection and treatment methods which focus on producing less waste and in effectively managing waste which is still produced;
- handling all materials in the solid waste stream rather than focusing solely on specific materials or sources of materials (Hazardous materials should be dealt with within the system, but in a separate stream)
- being environmentally effective through reducing the environmental burdens such as emissions to air, land and water;
- being economically affordable by driving costs out and adopting a market-oriented approach by creating customer-supplier relationships with waste products that have end uses and can generate income;
- social acceptability by incorporating public participation and ensuring individuals understand their role in the waste management system.
  (McDougall et al., 2001)

Due to the varying needs and challenges faced by organization in the ICI sector, a flexible yet comprehensive approach is needed to manage waste properly. Using a wide range of waste management options as part of a comprehensive integrated waste management system allows for improved ability to adjust to changing environmental, social and economic conditions (McDougall et al., 2001).

Forming an IWM plan can be a complex undertaking. Those responsible for designing IWM systems must have a clear understanding of their goals and objectives and ensure that terminology and activities are clearly defined in the plan. The next step requires identifying the range of potential options that are suitable for managing waste with cost estimates, risk assessments, available processing facilities and potential partners, and the product standards which exist for the recycling of certain wastes. Public feedback in this step can help to assure the accuracy of assumptions made, and help to build public acceptance. The final step involves examining the tradeoffs which exist among the available options given what is known about the risk, cost, waste volumes, and potential future behaviour changes (Tchobanoglous et al., 2006). Once these details are known, a comprehensive IWM strategy can be formed.

Systems analysis can provide information and feedback that is useful in helping to define, evaluate, optimize and adapt waste management systems (Pires et al, 2010). There are two main types of systems analysis techniques relevant to waste management systems:

- systems engineering models such as cost benefit analysis, forecasting models, simulation models, optimization models, integrated modeling systems
- system assessment tools such as management information systems, decision support systems, expert systems, scenario development, material flow analysis, life cycle assessment, risk assessment, environmental impact assessment, strategic environmental assessment, socioeconomic assessment (Pires et al., 2010)

Waste Diversion & Waste Minimization

The three R's are commonly used terms in waste management; they stand for "reduce, reuse, and recycle". As waste generation rates have risen, processing costs increased, and available landfill space decreased, the three R`s have become a central tenet in sustainable waste management efforts (El-Haggar, 2007; Seadon, 2006; Suttibak & Nitivattananon, 2008; Tudor et al., 2011).

The concept of waste reduction, or waste minimization, involves redesigning products or changing societal patterns of consumption, use, and waste generation to prevent the creation of waste and minimize the toxicity of waste that is produced (USEPA, 1995). Common examples of waste reduction include using a reusable coffee mug instead of a disposable one, reducing product packaging, and buying durable products which can be repaired rather than replaced. Reduction can also be achieved in many cases through reducing consumption of products, goods, and services. The most effective way to reduce waste is by not creating it in the first place, and so reduction is placed at the top of waste hierarchies (USEPA, 2010). In many instances, reduction can be achieved through the reuse of products. Efforts to take action to reduce waste before waste is actually produced can also be termed pre-cycling (HRM, 2010).

It is sometimes possible to use a product more than once in its same form for the same purpose; this is known as reuse (USEPA, 1995). Examples include using single-sided paper for notes, reusing disposable shopping bags, or using boxes as storage containers (UC Davis, 2008). Reusing products displaces the need to buy other products thus preventing the generation of waste. Minimizing waste through reduction and reuse offers several advantages including: saving the use of natural resources to form new products and the wastes produced in the manufacturing processes; reducing waste generated from product disposal; and reducing costs associated with waste disposal (USEPA, 2010).

Not all waste products can be displaced and even reusable products will eventually need to be replaced. It is inevitable that waste will be created as a by-product of daily human living (Kim, 2002), but in many cases it is possible for this waste to be diverted and recycled into valuable new materials. Glass, plastic and paper products are commonly collected and reformed into new materials and products. Recycling products offer many of the benefits of waste reduction efforts (displacing new material usage, reducing waste generated and the costs associated with disposal) but recycling requires energy and the input of some new materials, thus placing it lower on the waste hierarchy than reduction and reuse (UC Davis, 2008; USEPA, 2010).

Many waste management frameworks seek to incorporate the three R's in some capacity. In the UK, North America, throughout Europe and in parts of Asia, waste hierarchies are being incorporated which promote the adoption and use of "reduce, reuse and recycle" initiatives (Allwood et al., 2010). Waste management hierarchies (Figure 1) place the highest priority on waste prevention, reuse, and then waste recovery. Disposing materials in a landfill is the least desirable of the options (ECOTEC, 2000).

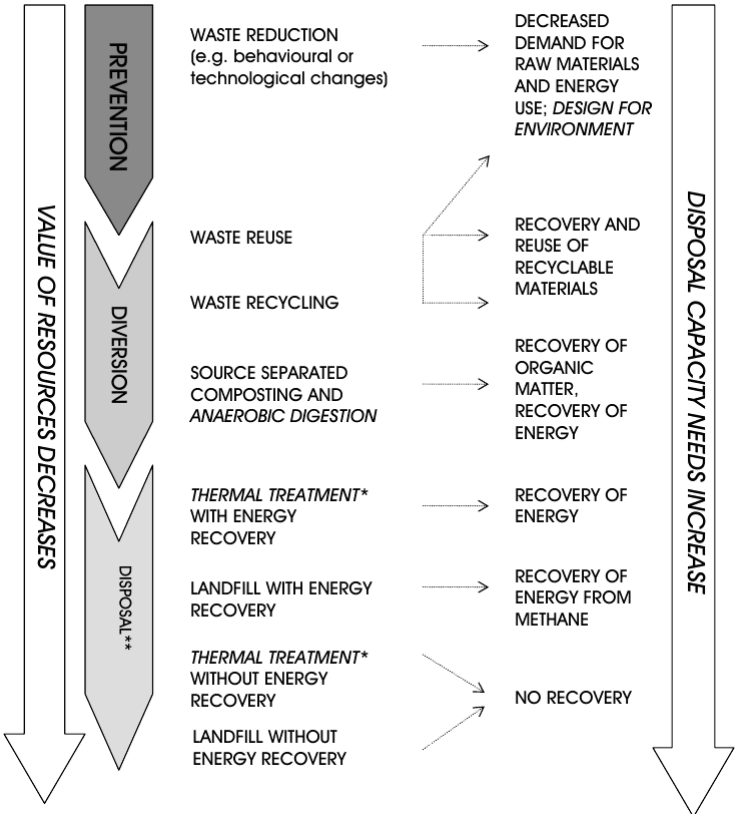


Figure 1: Waste management hierarchy (CIELP, 2008)

In some instances, additional R`s can be added to the basic three. Some organizations have chosen to add a fourth R (Concordia University, n.d.; FNQLSDI, 2008; UC Davis, 2008; U of T, 2008). The fourth R can represent different words including rebuy (UC Davis, 2008), rethink (Concordia University, n.d.; U of T, 2008), and recover (FNQLSDI, 2008). The concept of rebuy refers to consumer purchasing decisions. Consumers have the ability to take steps to improve waste management by helping to close the loop in waste management systems by purchasing products which have been recycled or used (UC Davis, 2008). Rethink is added to the three R's by some because changing our behaviour and our actions can lead to improvements in waste management. Changing consumption patterns and considering the impacts of our actions can lead to decreased production of waste, and even a reduction in waste management and waste minimization efforts (Concordia University, n.d.).

Recover can refer to methods which use and process waste so that it is used rather than disposed of (which would include reuse and recycling); however, it can also include recovering energy form waste before it is disposed. Waste can be processed into a fuel and used to produce a usable form of energy (FNQLSDI, 2008). Examples include incinerating waste to generate electricity, breaking waste down with (high temperature) plasmolysis to produce usable sources of fuel, or breaking down organic matter with anaerobic digestion to produce biogas.

These additional concepts do not need to be limited to 4 R's. El-Haggar (2007) proposes that to achieve sustainable waste management, a 7R methodology should be adopted: Reduce, Reuse, Recycle,

Recover, Rethinking, Renovation, and Regulation. Renovation refers to taking action to develop innovative ways to process waste, while regulation is added in recognition that it is a driving force behind ensuring the implementation of responsible waste management practices (El-Haggar, 2007).

KEY CONCEPTS

There are many key concepts which may be used to help structure a waste management plan. There are similarities and overlap between these different concepts, and each has their strengths and weaknesses, but the suitability of any given option must be assessed and determined by the responsible decision-makers.

Zero Waste

Zero waste refers to waste management and planning approaches which emphasize waste prevention as opposed to end of pipe waste management (Snow & Dickinson, 2001; Spiegelman, 2006). Zero waste encompasses more than eliminating waste through recycling and reuse; it focuses on restructuring production and distribution systems to reduce waste (C.Y. Young et al., 2010). An important consideration of the zero waste philosophy is that it is more of a goal, or ideal rather than a hard target. Even if it is not possible to completely eliminate waste due to physical constraints or prohibitive costs, zero waste provides guiding principles for continually working towards eliminating wastes (Snow & Dickinson, 2001) and there are many successful cases around the world which resulted from the implementation of the zero waste philosophy (Townend, 2010). The zero waste philosophy has been adopted as a guiding principle by several governmental organizations as well as industries (Snow & Dickinson, 2001; Townend, 2010).

Because the focus of zero waste is on eliminating waste from the outset, it requires heavy involvement primarily from industry and government since they are presented with many advantages over individual citizens. In fact, zero waste will not be possible without significant efforts and actions from industry and government (Connett & Sheehan, 2001). Industry has control over product and packaging design, manufacturing processes, and material selection (Townend, 2010). Meanwhile, governments have the ability to form policy and provide subsidies for better product manufacturing, design and sale; and the ability to develop and adopt comprehensive waste management strategies which seek to eliminate waste rather than manage it (Snow & Dickinson, 2001). Due to the heavy involvement of industry in eliminating waste, extended producer responsibility is often an essential component of zero waste strategies (Spiegelman, 2006).

ZERO WASTE

In 2002 New Zealand adopted the New Zealand Waste Strategy which included a zero waste objective. New Zealand was one of the first countries to adopt a national goal of achieving zero waste and with their strategy the country was able to make considerable progress. There were some difficulties in measuring progress and success towards their goals, and so today New Zealand has replaced their zero waste vision with a strategy that focuses on reducing harm and increasing efficiency (Ministry for the Environment, 2010).

A number of companies have successfully embraced the zero waste concept including Hewlett-Packard, Kimberly Clark, and The Body Shop (RCBC, 2002).

Cradle-to-Cradle / Cradle-to-Grave

Cradle-to-grave (C2G) is a term used to describe the linear, one-way flow of materials from raw resources into waste that requires disposal. Cradle-to-cradle (C2C) focuses on designing industrial systems so that materials flow in closed loop cycles; meaning that waste is minimized, and waste products can be recycled and reused (Figure 2). C2C focuses on going beyond simply dealing with issues by addressing problems at the source and by re-defining problems (McDonough et al., 2003). There are three key tenets to C2C: waste equals food, make use of solar income, and celebrate diversity (McDonough et al., 2003).

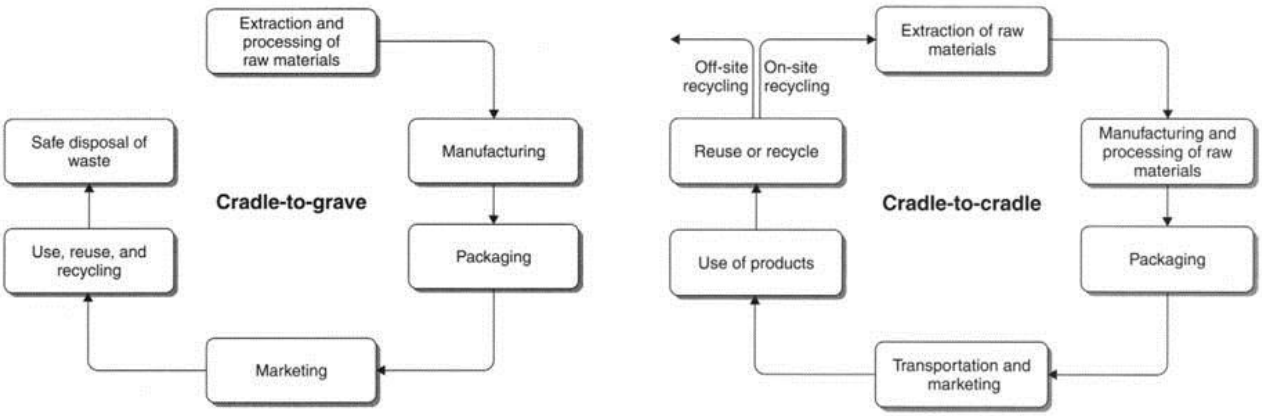


Figure 2 : Cradle-to-cradle systems strive to reuse products and recycle waste products into base materials for new products (El-Haggar, 2007)

The concept of using waste as a feedstock for different processes is a common theme in various types of waste management frameworks and concepts, such as recycling and industrial symbiosis. In natural ecosystems, nutrients are cycled through an ecosystem because the waste generated by certain organisms is typically used or consumed by other organisms. This process is referred to as the biological metabolism of an ecosystem. Through innovation, planning and design, the technical metabolism (the cycles and exchanges of products, goods and services in manufacturing processes) can be designed to make use of available wastes, thus mimicking natural processes observed in biological systems (McDonough et al., 2003). Ideally, C2C focuses on designing a technical metabolism which is characterized as a closed-loop system with resources traveling through cycles of production, use, recovery and remanufacture (McDonough et al., 2003).

Green engineering focuses on achieving sustainability through science and technology. It aims to reduce pollution at the source, and minimize the risks faced by humans and the environment when designing new products, materials, processes and systems (Anastas & Zimmerman, 2003; Vallero & Brasier, 2008). Green engineering is based on principles which are broadly aimed at designing materials and processes so that they can be used as a feedstock in industrial processes through product re-design and improvement to maximize their reusability at various scales (Anastas & Zimmerman, 2003).

Eco-Efficiency

An eco-efficiency framework focuses on integrating environmental and economic dimensions of certain developments, activities or processes (Hellweg et al., 2005), encouraging the creation of value with less impact (WBCSD, 2000). Eco-efficiency is not a specific framework or management system that can be used to manage waste (WBCSD, 2000). It is a management philosophy that can be used in conjunction with other frameworks to measure environmental and economic performance (Hellweg et al., 2005), showing how economic activity deals with nature (Schoer & Seibel, 2002). Eco-efficiency can be described mathematically as:

$$\text{Eco-efficiency} = \frac{\text{value added}}{\text{environmental impact}}$$ (Bohne et al., 2008)

The concept of eco-efficiency has 3 broad objectives: reducing the consumption of resources by minimizing material inputs and ensuring closing materials loops; reducing environmental impact by minimizing pollution and fostering the sustainable use of resources; and increasing the value of products and services by offering products which meet consumer needs while requiring fewer materials and resources (WBCSD, 2000a).

There are indicators which can be used to help measure eco-efficiency. Indicators will generally fall into one of two categories: economic performance or environmental influence. Some of the more generally applicable indicators pertaining to economic performance include product quantities, sales and net profits. Indicators pertaining to environmental influence include energy consumption, material

consumption, water consumption, ozone depleting substances emissions, and greenhouse gas emissions and total waste produced, waste to landfill, waste to incineration, and packaging amounts (WBCSD, 2000b).

Applying eco-efficiency to waste management systems requires special considerations because the applicability of eco-efficiency indicators, traditionally described by the ratio of economic value added to environmental impact added, is limited with regard to end-of-pipe treatment technologies and processes. End-of-pipe technologies are designed to remove or manage pollutants after they have been created, and typically occur at the last step of a process with no financial benefit to be expected. To deal with the challenges presented by these types of technologies, Hellweg et al. (2005) propose using a measurement of environmental cost efficiency (ECE) to more accurately describe the environmental benefits gained per additional costs involved. ECE indicators measure the environmental benefits of a given technology over another per additional unit of cost.

Ultimately, the specific indicators being used in an eco-efficiency centered framework will be determined on a project-by-project basis and will vary according to the data available and the nature of the materials and processes being examined (Schoer & Seibel, 2002).

Industrial Ecology

Industrial ecology (IE) is defined as “an approach to the design of industrial products and processes that evaluates such activities through the dual perspectives of product competitiveness and environmental interactions” (Graedel & Allenby, 2010, p. 391). IE is similar to eco-efficiency in that it examines economic and environmental aspects of activities and processes, but it has a strong engineering oriented focus on redesigning, integrating, and adapting technology to be more sustainable in a fashion similar to C2C. The discipline of IE has some specific tools and techniques which are practical for use in waste management, particularly with the development of eco-industrial parks through industrial symbiosis.

An eco-industrial park is a network of firms that cooperate with each other to improve economic and environmental performance by minimizing the use of energy and raw materials through the planned materials and energy exchanges (Côté, 1998). The network of physical processes and relationships between firms which is responsible for the conversion of raw materials and energy into finished products and wastes is known as an industrial metabolism.

Industrial symbiosis (IS) describes a relationship between two or more firms where the unwanted by-products of one firm are used as a resource by another (Graedel & Allenby, 2010). Chertow (2007) defines IS as requiring a minimum of three separate entities exchanging at least two different resources. This definition differs significantly in that it does not recognize one-way linear exchanges as examples of IS.

Industrial symbiosis mimics biological systems by using by-products of the industrial metabolism which would otherwise be discarded as waste as useful resources for other firms. The focus on product and resource recycling and reuse helps to create closed loop systems which produce less waste and require

fewer inputs of natural resources and energy. There are five different categories of industrial symbiosis (Table 2) which are classified according to the spatial scale of the relationships of the firms involved, or the nature of the products being exchanged (Chertow, 1998; Graedel & Allenby, 2010).

Table 2: The five categories of industrial symbiosis

Category 1	Occurs through waste exchanges where recovered materials are sold or donated to another firm. These exchanges are unplanned and so may not be considered a true example of IS
Category 2	Involves the exchange of materials within a single facility, firm or organization, but between different processes.
Category 3	Co-located firms in a defined industrial area exchange materials and resources
Category 4	Firms in relative proximity to each other engage in the exchange of materials and resources
Category 5	Firms organized across a broad spatial region exchange materials and resources (there has not been a successful category 5 IS to date)

INDUSTRIAL ECOLOGY (SYMBIOSIS)

The Kalundborg industrial ecosystem in Denmark has been evolving since 1982. The development of relationships in Kalundborg began by diverting steam from a coal fired power plant to nearby businesses. As the park developed over the years, the businesses in the area formed relationships with each other, with waste products from one becoming raw materials for another. This industrial ecosystem is praised as being a leader in environmental and economic performance (Ehrenfeld & Gertler, 1997).

Summary

From reviewing the literature, it is clear that key management frameworks have evolved from a variety of disciplines from engineering to ecology. Some are more inspirational in form while others are process focussed. The function and culture of the organization will help determine the appropriate waste management framework for an ICI organization. For example, an institutional environment would differ from an industrial setting which can differ from the commercial sector. In an institutional setting a wide-range of products are used creating large volumes of a number of streams from hazardous to construction and demolition waste. Hundreds of people are involved in procurement and sorting waste at stations. In a setting like a university, each year there is a larger turnover of students. The need for constant education is pressing. Materials are used rather than created.

In an industrial setting, focus is on the creation of a product. The opportunity for waste efficiency and reuse is more streamline and perhaps easier to control with less individual actors. The diversity of the stream may be comparable to the ICI sector. In a commercial setting, the diversity of the stream may be less but individual actors may be of a similar nature to the institutional sector.

Given the difference in the nature of the sector and actors involved, the application and suitability of some waste management frameworks would differ by sector. This is reflected in examples such as government switches from zero waste to indicator-based frameworks.

GOALS, OBJECTIVES, INDICATORS, TARGETS, STRATEGIES

Defining and establishing clear goals is the first step of creating a waste management program. Knowing what the waste management plan aims to achieve before it is designed can make the scoping process much simpler. Goals which are in line with the interests and core principles of an organization should be identified (USEPA, 1995). Source reduction is an example of a key goal as it eliminates the need to manage the waste and can cut costs.

Once goals have been defined, baseline data is needed to establish suitable objectives, indicators and targets. Baseline data is obtained by conducting waste characterization studies and with this data suitable system components can be identified. This information provides insight as to where efforts will need to be focused to gain the most benefit (USEPA, 1995). Common goals, objectives and strategies from waste management plans of the ICI sector are highlighted below (Table 3).

Table 3: Summary of key goals, objectives, indicators, targets and strategies outlined in various waste management frameworks.

Goals / Objectives	Indicators / Targets	Strategy
Minimize waste generation [123]	• Reduce the quantity of waste generated per capita [1] • Eliminate unneeded materials [26] • Systematize solid waste reduction and management practices into standard operating procedures and packaging/product specifications [2] • Assess waste generation potential of new developments [3]. • Achieve ISO 14001[6].	• Advocate for transfer of additional waste management responsibilities to producers and consumers [1]. • Reduce or eliminate materials entering the solid waste system which hinder or limit the opportunities to achieve reuse, recycling, or energy recovery, or that may exacerbate environmental impacts of disposed residuals [15]. • Provide information and education on options to reduce waste [1]. • Evaluate shipping and packaging procedures to identify items which could be eliminated or reduced [2]. • Document details of the campus waste stream and review regularly so that trends can be assessed [3]. • Outline the roles and responsibilities of all stakeholders involved with waste management [7]. • Develop and implement an ISO 14001 strategy[6].
Maximize reuse, recycling and material recovery [1245]	• Increase the waste diversion rate [15]. • Use alternate materials which reduce production impacts [2]. • Substitute reusable items for disposable items in shipping, handling, storage and operations [2].	• Increase the opportunities for reuse and recycling [12]. • Increase the effectiveness of existing recycling programs [1]. • Target specific materials for reuse, recycling and material recovery [125]. • Target specific waste streams (such as C&D waste) for increased diversion [1]. • Target specific sectors to improve diversion rates [1]. • Utilize non-recyclable material as fuel to provide electricity and district heating from waste-to-energy facilities [1]. • Develop reusable containers for shipping [2]. • Outline the roles and responsibilities of all stakeholders involved with waste management [7].
Develop waste management practices in cooperation with the community [35]	• Develop waste management plans in consultation with participant groups [3]. • Include communication links so that people can inform each other when their activities change which have an impact on waste management [3]. • Form a working group to coordinate the development of	• Create materials and tools to target community members and groups [35]. • Hold activity sessions detailing the importance of waste management and what people can do [3]. • Inclusion of summary of what is expected of staff in their employment orientation [3]. • Develop communication links between different groups involved in waste

	specific area / group plans [3]. • Work with regional organisations to minimise duplication of resources and facilities [3].	management activities. It is essential that all those involved in specific waste activities (such as purchasing, collection, storage, and disposal) know what others are doing. This will avoid both gaps and overlaps [3]. • Identify options for cooperative product purchasing, including price and discounts for bulk purchases [3]. • Invite comment from regional organisations and businesses [3].
Adjust procurement policies so they are reflective of commitment to waste management principles [3]	• Use the commitment to waste management as a lobbying point when pursuing funding for capital works [3]. • Support a policy of reducing the 'front end' of the waste stream [3]. • Develop regional alliances to maximise purchasing power and encourage waste avoidance specifications for products [3].	• Develop purchasing guidelines consistent with the waste management strategy [3]. • Design tender specifications in such a way that those submitting tenders can address waste management issues [3]. • Identify regional bodies that have similar purchasing requirements [3].
Develop educational programs [3456]	• Involve the community through increasing awareness, meeting specific information needs, and fostering a sense of community commitment [35]. • Foster competency amongst waste management staff in the identification of opportunities for avoidance and minimisation of waste currently being disposed of [37]. • Ensure that operational staff have the training to comply with relevant guidelines or legislation, and the support to report negative events or failures of the system [37].	• Conduct waste characterization studies to establish was reduction goals [2]. • Track diversion progress and make information available [2]. • Develop marketing program to attract regional organisations to participate [3].
Ensure waste management is safe and effective [356]	• Develop a combined environmental committee and health and safety committee [6]. • Ensure compliance with regulations [37]. • Assign responsibility for the regular review of the available technologies for waste storage and disposal [3].	• Document the segregation, containment, storage, collection, and disposal mechanisms for each category of waste, with particular attention paid to harmful categories [35]. • Develop accident response strategies for harmful categories of wastes and provide training for those who will be responsible for carrying them out [3]. • Provide staff training [37].
Become a regional leader in waste management [3].	• Support regional waste management initiatives [3]. • Commit to environmental excellence beyond regulatory requirements [6].	• Document a waste management 'wish-list' that includes options, costs and benefits, and parameters that need to be met before each option can be actively considered [3]. • Advertise waste management initiatives. This should not be overstated and should include discussion of the limitations [3]. • Invite comment from regional organisations and businesses [3].

[1] (Metro Vancouver, 2010)
[2] (Environmental Defense - McDonald's Waste Reduction Task Force, 1991)
[3] (University of the Sunshine Coast, 2010)
[4] (Nova Scotia Environment, 2009)
[5] (University of Victoria, 2004)
[6] (Polycello, n.d.)
[7] (Halifax Regional School Board, 2009)

STRATEGIES

There are several different types of strategies which can be implemented to carry out waste management plans. Strategies can be classified according to the general avenue through which they aim to make change occur. Strategies can typically be classified as working through command and control approaches, economic incentives and stimulation of innovation in the market place, and information and educational efforts (CEF Consultants, 1994). Some examples are discussed below.

Command and Control

Command and control strategies such as legislation and enforcement create a set standard and minimum guideline for all to follow. There are international, national, provincial and municipal regulations that define how materials and waste should be handled, diverted, and transported. Examples include laws to ban items and materials from landfill (such as outlined in the NS Solid Waste-Resourc e Management regulations) and pollution control regulations (such as the Canadian Environmental Protection Act) (CEF Consultants, 1994) and strategies such as the enforcement of extended producer responsibility (EPR) in some countries have seen reductions in reduction in packaging.

Extended Producer Responsibility

Extended producer responsibility (EPR) is a concept that requires industries to internalize the externalities associated with production of their products (Sachs, 2006). When incorporating EPR, businesses are assigned the responsibility for the environmental impacts across the life cycle of their products (Fishbein et al., 2000). Assigning the responsibility to industry to manage the environmental impacts of their products provides incentive to develop and incorporate environmentally friendly designs for products; meaning waste is reduced from the outset and products can be redesigned to be easier to recycle (CCME, 2009) promoting the creation of closed loop systems (Fishbein et al., 2000).

In practice, EPR is essentially a take-back program where producers are responsible for managing their products after they have reached the end of their life cycle. Although the concept is relatively simple, applying and implementing EPR has been met with difficulties, particularly in the United States where legislation is curtailed more towards regulating industrial processes than products (Sachs, 2006). The United States has developed Extended Product Responsibility which differs from Extended Producer Responsibility in that: it does not place the onus solely on producers to manage their products in the post-consumer stage, responsibility is not required to be physical or financial and can consist of providing consumer education, and participation is voluntary (Fishbein et al., 2000). Extended product responsibility is broader in that it includes more stakeholders and does not focus on the post-consumer stage of products. According to the U.S Environmental Protection Agency (1998), the shared responsibility of all actors in the supply chain is crucial to making long term environmental improvements in production systems; however, concerns have been expressed that making everyone responsible for everything can result in nobody being responsible for anything (Fishbein et al., 2000).

In Canada, it is possible that market signals may not be sufficient on their own for ensuring that EPR is adopted, and so legislation, policy and programs are essential for successful implementation. A Canada-wide action plan for EPR has been developed by the Canadian Council of Ministers of the Environment (CCME) outlining guiding principles, priority actions, and its purpose is to extend EPR across the nation in a consistent and coordinated manner. In the action plan, the CCME has adopted the definition of EPR as being "...an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle." (CCME, 2009, p. 3).

EXTENDED PRODUCER RESPONSIBILITY

The diary industry is an often cited example of successful EPR gone awry. Traditionally, diary companies delivered full bottles of milk to homes and collected empty bottles to be rinsed and reused. The costs were absorbed by the dairy company or reflected in the cost of the milk. However, energy costs may be lower for packaging in this instance, even if the packaging is wasted.

Today, milk is delivered to stores in disposable cartons. The cost of managing the waste has been transferred from the dairy company to consumers who must pay for municipal handling of the waste (SNC - Lavalin, 2007)

JAPAN

Since 2000, Japan has passed a series of laws promoting the recycling of waste including: the Basic Law for Promoting the Creation of a Recycling-Oriented Society; the Revised Waste Management Law; the Law for the Promotion of Effective Utilization of Resources; and the Green Purchasing Law (Barlaz, Loughlin, & Lee, 2003).

Federal Law and Policy

The policy environment which governs waste management in Nova Scotia is primarily reflective of legislation enacted at the provincial level and decisions made in pertinent case law. Federal involvement in waste management efforts focuses on transboundary waste since most waste management falls under provincial jurisdiction and authority under the division of federal and provincial powers outlined in *The Constitution Act* (1867). The Federal government is involved with the regulation and management of certain types of toxic substances, pollutants and wastes through the *Canadian Environmental*

Protection Act (CEPA, 1999). The Federal government also regulates the Hazardous Products Act *(HP*A) which requires a supplier to provide WHMIS labels and material safety data sheets (MSDSs) for a controlled product at the time of (or prior to) sale or importation. The Federal government is able to influence waste management in provincial jurisdictions by developing national goals, policies and funding programs.

In the late 1980's, municipal solid waste was being focused on by the media as a major problem in Canada and in 1989, the Canadian Council of Ministers of the Environment (CCME) adopted a national waste diversion goal of 50% by the year 2000 and developed a National Packing Protocol which aimed to reduce packaging waste by 50% by the year 2000 (Wagner, 2007; Wagner & Arnold, 2008). Around the same time, waste management in Nova Scotia was becoming an increasing concern in the media and for citizens. The provincial government adopted the CCME waste diversion goal and opted to develop a waste management strategy that focused on waste recovery and waste minimization rather than expanding and improving disposal options (Wagner, 2007).

Although the federal government plays a role in hazardous waste management, regulation is left to provincial governments. Across Canada, provinces may use different definitions for what qualifies as a hazardous waste and there may be substantial differences regarding the extent to which regulations surrounding their use and disposal are enforced (Meakin, 1992). The *Dangerous Goods Management Regulations* enabled under the *Environment Act* define which types of substances and materials are considered hazardous in Nova Scotia. These *Regulations* draw from the federal level *Transportation of Dangerous Goods Regulations* which are created under the *Transportation of Dangerous Goods Act*.

Provincial Law and Policy

In 1994, Lunenburg Country became the first jurisdiction in Nova Scotia to create a waste management system that required waste to be source separated into 3 distinct streams. They opened the first centralized commercial scale composting facility in North America. In 1995, a Community Stakeholder Committee (CSC) was tasked with examining alternative waste management scenarios in Halifax Regional Municipality (HRM). Lunenburg's system was influential to the CSC which was charged with determining how municipal solid waste should be managed and in the end the CSC recommended that the new waste management strategy for HRM be focused on maximizing the recovery of materials from waste (Wagner, 2007).

In 1995, the province passed the *Environment Act* which contained provisions stipulating that the province was to form a solid-waste management strategy, achieving a 50% landfill diversion rate, and allowing for the creation of regulations to enforce waste management initiatives. Later that year, the Solid Waste-Resource Management Strategy was released and formally adopted by the government.

The *Activities Designation Regulations* (1995), enabled under the *Environment Act*, outline what constitutes a waste management facility and a dangerous goods/waste handling facility. These *Regulations* also state that municipal solid waste excludes inert construction and demolition (C&D) debris. According to the construction and demolition debris disposal site guidelines, C&D facilities and debris disposal sites must receive approval before beginning operation, and they may only accept C&D waste unless approval is given by the minister to accept other types of waste (NSEL, 1997)

The *Solid Waste-Resource Management Regulations* (*SWRMR*, 1996), enabled under the Nova Scotia *Environment Act* (1995), introduced measures in law to improve waste management in the province and

allow for compliance with the Solid Waste Management Strategy (Figure 3). The *SWRMR* introduced several significant provisions such as banning certain materials from landfills and incinerators including organics and other recoverable materials, prohibiting the open burning of waste, and establishing regional waste management areas in the province. The 50% diversion target was amended in the *Environment Act* in 2006, added to the Environmental Goals and Sustainable Prosperity Act in 2007 and changed to achieving a solid waste disposal rate of 300kg/person/year or less by the year 2015. Nova Scotia had a disposal rate of 401kg/person in 2009-2010 and the province will require a 25% reduction from that rate to reach the target of 300kg/person. The province will be renewing and updating the waste management strategy to help meet this target (NSE, 2008a). These regulations are overseen by the Department of Environment.

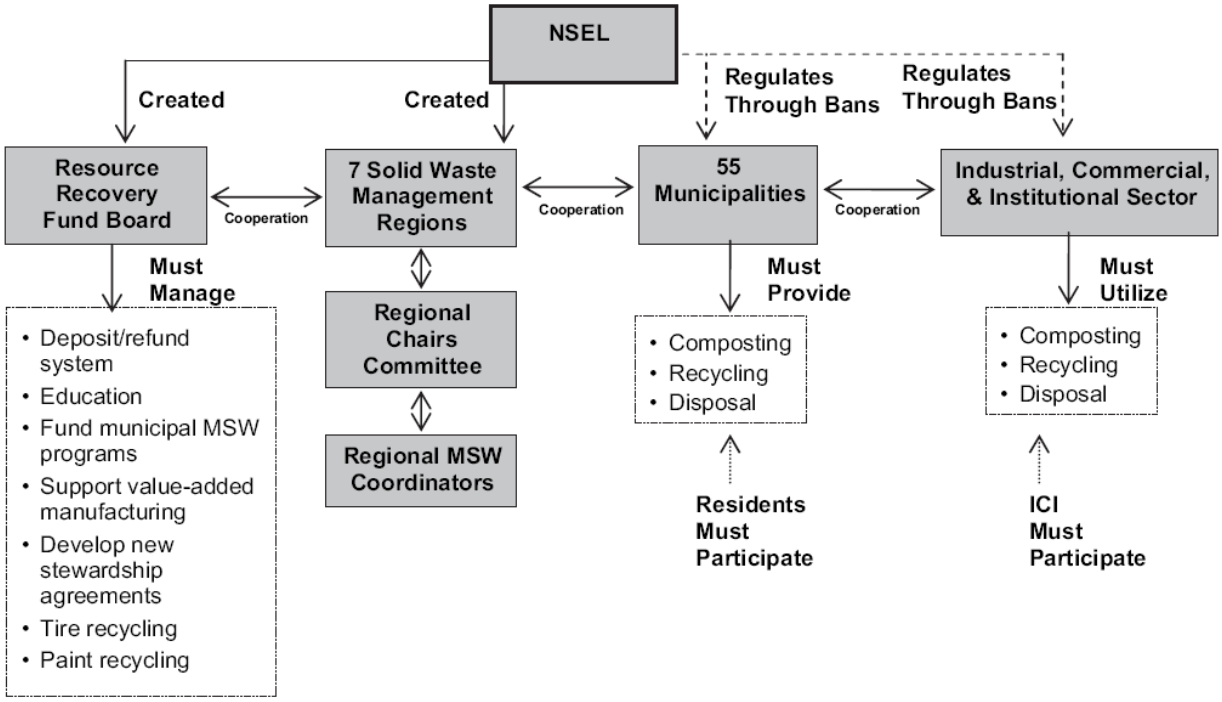


Figure 3: Nova Scotia's waste governance structure (Wagner & Arnold, 2008)

The *SWRMR* also established the Resource Recovery Fund and the Resource Recovery Fund Board (RRFB) which is responsible for overseeing the Fund. The RRFB is charged with developing: municipal or regional diversion programs; a deposit/refund system for beverage containers; industry stewardship programs; programs and materials to raise awareness for waste reduction, reuse, recycling and composting; and value-added manufacturing in the Province (NSEL, n d; *SWRMR*, 1996). In 2007, the *SWRMR* were amended to include restrictions on the disposal of other types of waste, most notably electronics. The amendments included the creation of an electronics stewardship program called the Atlantic Canada Electronics Stewardship (ACES) Program which is led by the RRFB to reduce, divert and recycle electronic waste.

The *Environmental Goals and Sustainable Prosperity Act* (*EGSPA*, 2007) is another avenue through which the provincial government plays a role in waste management. Although *EGSPA* does not contain

provisions which allow the government to enforce or regulate waste management, it does commit the government to achieving a variety of environmental objectives by the year 2020 and one of these objectives is to meet the 300kg/person/year disposal rate outlined in the *Environment Act* (Nova Scotia Government, 2010).

Municipal Law and Policy

As stated in the *Municipal Government Act* (*MGA*, 1998, ss. 49, 81, 325-326), municipalities are able to form their own by-laws and policies surrounding waste management. There are three primary avenues through which municipal authorities can impact waste management: enacting by-laws pertaining to waste disposal; passing regulations through local health boards, particularly regarding hazardous wastes;, and developing zoning by-laws for the citing of waste disposal and handling facilities (Meakin, 1992)

By-laws regarding waste disposal can be vastly different between municipalities. Although provincial regulations stipulate that C&D waste must be disposed at approved facilities municipalities may make by-laws regarding diversion and recycling targets. For instance, HRM has implemented by-laws requiring C&D waste disposal facilities to recycle or divert 75% of the C&D waste they process (HRM, 2001). Other municipalities do not have diversion requirements built into their by-laws for C&D facilities and this creates an unlevel playing field for waste diversion goals across different regions (Bauld, 2008). HRM has a flow control by-law to deal with this issue.

Provincial legislation defines C&D waste disposal methods and facilities. The Nova Scotia Environment Department does not regulate C&D processing sites – however, the processing may be written into approvals for disposal sites were C&D may be processed) . Diversion targets for C&D are left to the discretion of municipalities and individual waste management regions. Incentive to divert C&D waste from landfills is provided by the RRFB as they provide credits and funding to municipalities for C&D waste diverted from landfill (NSE, 2009; Walker et al., 2004).

Even though HRM is making the effort to reduce waste disposal by imposing C&D waste diversion requirements in their waste management plan, efforts may be hindered if waste is shipped outside the region to be processed. To help prevent this from happening, HRM has passed by-law S602, requiring all C&D waste generated within the region to be processed within HRM's municipal boundaries at certified facilities. This ensures that the waste is diverted from landfill, and also that HRM receives the diversion credit from the RRFB (Walker et al., 2004). It is important, particularly for the ICI sector, to be aware of by-laws and policies which may be in effect in their regions to ensure they are in compliance.

Waste Management Regions

The *SWRMR* require the creation of seven waste management regions in the province (Figure 4). The intent is to encourage regional cooperation within each region, thus allowing for improved waste diversion and management and decreased costs (NSEL, n.d.). The municipalities within each region are required to formulate and implement waste management strategies which must be approved by the Administrator of the region (designated by the Minister of Environment). Each municipality must also provide the Administrator with: reports on progress towards the goals of the *Environment Act;* an

account of how solid waste is being disposed of; and outline their public awareness programs being used (*SWRMR*, 1996, S. 40).

Municipalities are permitted to make changes in the distribution of the regions. For these changes to be accepted, the Administrator of the region must be of the opinion that the viability of the region is not affected. Because each region is allowed to design its own plan, there is some variation in waste management between regions which can result in different substances and materials being classified as recyclable or compostable between regions. It can also call for different levels of compliance between regions (RRFB, n.d. a). These differences can be traced back to by-laws formed at the municipal level.

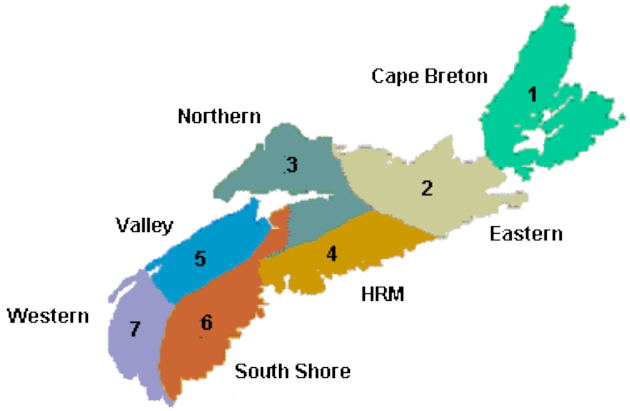
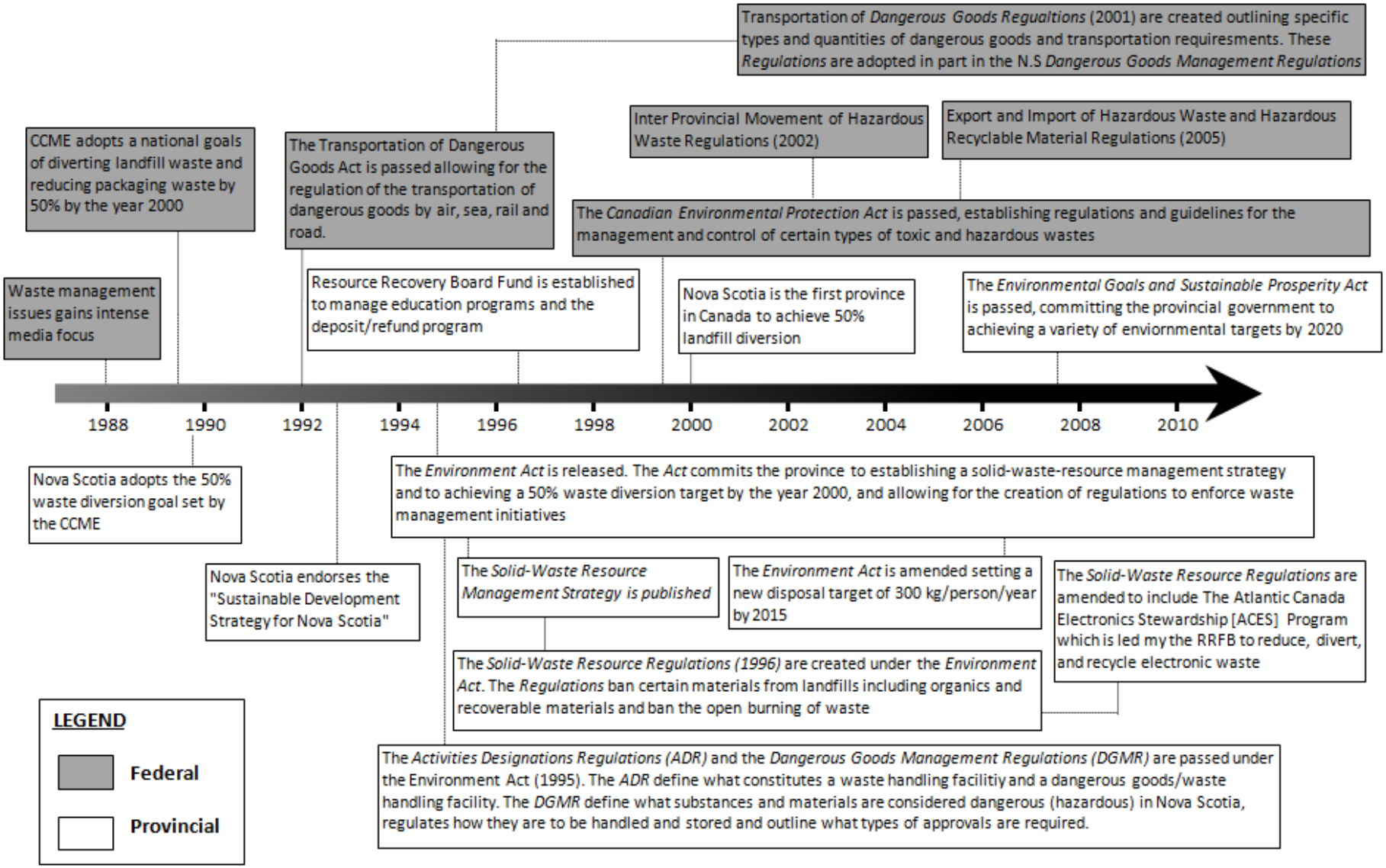


Figure 4: Nova Scotia's waste management regions (Source: RRFB.com)

Enforcement and Compliance

Since adopting the new comprehensive provincial waste management strategy in 1995, Nova Scotia has become one of the leading waste management systems in North America (Wagner & Arnold, 2008). The strategy has required significant regulation to both the residents and ICI sector in Nova Scotia. Part of this regulation has included placing strict restrictions and bans on what can be placed in landfills in the province.

Figure 5: Key legislation and events pertaining to waste management in Nova Scotia (Gary Davidson, 2011)



Economic Instruments and Institutional Innovation

Policy can help create change through the implementation of economic instruments and programs that encourage institutional innovation. Economic instruments can take the form of taxes, while innovation can be stimulated through investments in program funding for emerging technologies (CEF Consultants, 1994). Economic instruments have been shown to have a direct influence on waste management systems (Bilitewski, 2008; Goddard, 1995; Skumatz, 2008; USEPA, 1994) as well as recycling behaviour (Bolaane, 2006; Frey et al., 1997; Iyer & Kashyap, 2007) which is a critical component to waste management systems. In some instances, incentives can also be provided by third-party organizations. Many organizations choose to construct their buildings to LEED (Leadership in Energy and Environmental Design) certification as part of their stewardship programs, and waste management can be used to obtain several points towards LEED certification (CAGBC, 2009).

Incentives and Policies

All levels of government can take significant steps to implement policies which impact waste management, particularly with demand-side and supply-side policies (Table 4). Demand-side policies can be enabled to stimulate the demand for recyclables. Examples include government procurement guidelines, and reduced tax rates for recyclables and products with recyclable content. Supply-side policies can provide financial incentives to residents and business through initiatives like deposit-refund programs, disposal taxes, and use-based waste management fees (Loughlin & Barlaz, 2006).

Table 4 : Policy based incentives which may be implemented to increase recycling rates (Barlaz, Loughlin, & Lee, 2003; Loughlin & Barlaz, 2006)

Supply based policies	Demand side policies	Policies targeting supply and demand
• Mandatory public participation • Mandatory ICI source separation • Landfill bans for certain materials • Use based pricing • Disposal taxes • Deposit-refund programs	• Recycled content mandates • Procurement guidelines • Product stewardship • Voluntary agreements	• Extended producer responsibility • Environmental management systems

Specific groups may also be targeted with incentives and policies (Liss, 2000). For example, businesses can be offered municipal waste service if they are small enough, or be required to produce recycling plans which outline what materials are recycled, overall costs for solid waste disposal, and identify the largest fractions of their remaining wastes. Construction and renovation projects could also be targeted by requiring deposits to be paid in advance and only returned if recycling targets are met, and permitting fees for construction could be adjusted to cover the cost to the community for managing the waste that will be generated by new facilities. These types of incentives and policies can be implemented by government, or in some cases voluntarily adopted by firms seeking to act as leaders in waste management through procurement guidelines and in-house policies (Liss, 2000).

In Nova Scotia, a deposit-refund program is currently in place for beverage containers. This program is headed by the RRFB and covers all beverage containers which are ready to serve drinks, with the exception of milk. The incentive to recycle the container is placed on the consumer by refunding half of the value of the original container deposit that was paid when returned to a certified depot (Environment Canada, 2007). As a result of NSE regulations, the electronics industry has implemented an electronics stewardship program which requires consumers to pay an environmental handling fee on certain electronic devices at the time of purchase. When the electronic device is no longer wanted or used, it can be brought to a depot free of charge. From there, the device is shipped off to a facility where it is broken down and recycled (ACES, n.d.).

Use-Based Waste Management Fees - Pay As You Throw

Pay as you throw (PAYT) waste management (also called use-based pricing, variable rate pricing, or unit pricing) has emerged as a way of reducing waste generated at the household level. Under the PAYT waste management system, users are charged a fee for waste collection and disposal. Generally, incorporating user fees ensures that those responsible for generating the waste are responsible for disposal costs (USEPA, 2009), and shifts some of the responsibility of waste minimization to citizens and producers (Park, 2009). PAYT systems have been implemented in many countries including: parts of America (USEPA, 2009); parts of New Zealand; in Taiwan (Snow & Dickinson, 2001); and in South Korea (Kim, 2002; ROKME, n.d.) and has been instrumental in reducing the amounts of municipal solid waste generated. This system entices waste generators to reduce the amount of waste they produce, and to recycle to avoid incurring additional charges (Kim, 2002; Miranda et al., 1994; USEPA, 1994). The charges can also be designed so that discounts are awarded to waste generators who produce limited amounts of waste, while heavy producers pay increasing rates per volume of waste as volumes increase (Liss, 2000).

The applicability of PAYT waste management frameworks will be limited in the ICI sector in Nova Scotia since firms are already complying with a partial PAYT framework. The ICI sector is not eligible for municipal waste service in most areas of Nova Scotia and is required to manage and dispose of all wastes they produce (NSE, 2008b). ICI sector organizations pay for collection, hauling and disposal charges which are calculated according to the mass of the material sent to the landfill, C&D sites, and compost facilities. Landfill waste have the highest tonnage fees, compared to other recycling and composting facility tipping fees. Other materials sent for recycling such as electronics, paint, and beverage containers do not have tonnage fees because upfront deposits paid by consumers are collected at point of sale and are used to administer recycling programs. Materials such as paper, cardboard, some plastics, waste veggie oil, and metals are accepted or collected for free because there is a market value for these products. Some ICI sector organization may also sell material directly to a buyer to receive money per tonne for these materials. Within organizations or firms, there may be potential to arrange PAYT systems for different departments by including waste management in their specific operating budgets thus shifting the onus of waste reduction to the individuals responsible for certain aspects of waste production (i.e.: office workers, shipping and receiving, production, kitchen staff).

(Environmental) Supply Chain Management

A supply chain is defined as "...the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer" (Mentzer et al., 2001). Incorporating environmental management techniques along the entire supply chain of a product is called environmental supply chain management (Hage, 2007). Environmental supply chain management can result in improved environmental performance by reducing collection, recovery and disposal of used products; but also in improved economic performance (Ilgin & Gupta, 2010). These initiatives are typically used to achieve one of four main outcomes: environmental outcomes, economic outcomes, cost reductions, and intangible outcomes (Eltayeb et al., 2010).

There are different motivations behind why private industries incorporate environmental considerations into supply chain management including increasing profits and being required to comply with regulations (Hage, 2007). In environmental supply chain management, there are several different initiatives which may be used, including: Eco-design or design for environment, green purchasing, supplier environmental collaboration, customer environmental collaboration, and reverse logistics (Eltayeb et al., 2010).

Education and Monitoring

Behavioural instruments play a role in waste management strategies through initiatives that inform and educate. Examples of these types of initiatives include waste audits, school programs, advertising, training, and competitions (CEF Consultants, 1994). Education has been shown to be a critical component in encouraging public participation in recycling programs (Bolaane, 2006; Grodzinska-Jurczak et al., 2006; UC Davis, n.d.).

Waste Characterization Studies

Information and education can shift behaviour and help garner public support for waste management initiatives and can also help to build expertise. There are a wide range of activities which may take place to further educational efforts. Waste characterization studies and waste audits are critical to the process of designing and implementing a waste management plan and to gain insight as to where diversion efforts should be focused (Armijo de Vega et al., 2008; Smyth et al., 2010). The results of waste characterization studies and waste audits can play a central role in educational campaigns that are used to foster support and motivation for waste diversion initiatives. The results of ongoing studies are also useful for evaluating progress towards achieving goals and objectives of a waste management plan, and also in helping to review previously established targets (CCME, 1996).

Behavioural

Educational and promotional tools such as staff education, event promotion and training are essential for the successful implementation of a waste management plan (CCME, 1996). Raising awareness about different waste management programs can have positive effects, but there are several methods which can be used to change behaviour to improve participation or correct problems (Timlett & Williams, 2008). Once new initiatives are introduced, people will need time to adjust until the new plan becomes normal behaviour, but once this behaviour is established it is difficult to break (Timlett & Williams, 2009).

Establishing certain behaviour patterns in transient populations such as student groups and military populations, and also in high density residential areas can be challenging. Targeted strategies which are aimed at specific areas and groups (Purcell & Magette, 2010) and which focus on providing instructions on how, what, and where efforts should be focused can result in greater success rates (Smyth et al., 2010). It is also important to take into account the socio-economic conditions of the group that is expected to participate in the program (Matsumoto, 2011).

Participation and perception towards different waste management plans can be impacted by a variety of factors including: the level of knowledge regarding the impacts of current and suggested actions; access to adequate facilities; adequate knowledge and expertise to carry out what is being asked; concern for the community ;and knowledge of the consequences or benefits of their actions (Davis et al., 2006; Hansmann et al., 2006; Thøgerson & Grunert-Beckmann, 1997).

It is possible to achieve significant short-term success in altering behaviour by implementing incentive based programs which offer a reward for participation (Timlett & Williams, 2008); however, behaviour changes brought about through these methods are not maintained in the long-term once the reward is removed (Kaplowitz et al., 2009). Personalized feedback has also been shown to result in behaviour change (Timlett & Williams, 2008)

In Nova Scotia, the Resource Recovery Fund Board has been created to develop and implement educational awareness programs to improve product stewardship, diversion rates, and source separation (Wagner & Arnold, 2008). At the municipal level, most municipalities in Nova Scotia including Halifax Regional Municipality have waste education officers to aid the general public and firms in the ICI sector learn about changes to local area waste management regulations and to focus educational efforts in problematic areas (HRM, 2011).

OPERATIONAL LOGISTICS

It is important to consider the components needed for successful implementation of a waste management plan. Components include collection and storage of material, equipment, signage, human resources (UC Davis, n.d.) including contracts with external waste service providers (CCME, 1996) transportation, materials processing, and material use.

Waste stream composition and quantity vary drastically across firms in the ICI sector. The waste stream for a corporate office will be drastically different from that of an industrial manufacturing complex; as such the system components of a waste management plan will vary accordingly.

Preliminary Considerations

Before a firm can design a waste management strategy, certain conditions must be met. The resources must be in place to undertake the design and implementation efforts of the strategy including human resources and capital. A commitment from management to support the policy is another component that is crucial to successful implementation. The responsibility of ensuring that the waste management plan is implemented and monitored is crucial. Some organizations may have large contracts in place with no designated person responsible for ensuring compliance with the plan; this can be particularly problematic when dealing with external waste service providers. An understanding of the current waste management practices is also required. This includes waste disposal activities, and gathering information on the contractors already involved with the current waste management framework (CCME, 1996; RRFB, 2008).

Collection, Storage, and Processing

Waste collection is a critical component to waste management. The economic and environmental performance of the entire system can be impacted by the way that materials are collected and sorted. In many instances, the collection point will be an interface where waste generators and waste collectors that must be carefully managed if the system is to be effective. Waste generators require waste collection with minimal inconvenience, while collectors must be able to collect waste in a way that is compatible with the planned treatment and processing methods if the waste management system is to be sustainable (McDougall et al., 2001).

Within many firms, waste is generally handled in one of two ways: custodial collection, or self-haul collection. Custodial collection involves custodial staff collecting and transferring of waste. This typically involves emptying out and maintaining publicly accessible collection bins and transferring them to a larger storage container which is typically located in a centralized area with controlled access. With self-haul collection systems, employees are responsible for ensuring that their waste is managed and sent to a collection point. This essentially means that there are no custodial staff who are responsible for handling waste. Employees are responsible for collecting and handling waste as part of their regular

duties. Examples of organizations which may not have dedicated custodial staff include restaurants, supermarkets and convenience stores. With organizations like this, a greater number of people are involved with managing and handling waste. This is an important consideration, particularly with respect to educational efforts. Storage containers and storage areas must have enough room to allow for the easy movement of collection carts, access to the larger storage bins, and compliance with health and safety regulations (CCME, 1996).

Equipment

There are many factors to consider when determining what equipment will be needed to ensure waste management efforts are successful. There are generally two types of equipment which will be required by an organization to manage waste: collection equipment which is used for collecting the generated waste materials; and processing equipment for reducing the volume of materials and for storage (CCME, 1996). Signage and labelling are other important considerations.

Collection Equipment

There are many different types of collection equipment which can be used for collecting waste materials for short-term storage (Table 5). The size and type of collection equipment most suitable for any firm will depend on a variety of factors such as: facility size, waste volume and weights, storage space available, characteristics of the waste being handled, and costs (CCME, 1996). The desired outcome will impact the chosen resources devoted to a waste management framework – ie: is the goal to increase diversion rates and maximize recycling and reuse; or is the goal to satisfy regulatory requirements?

The tools being used to manage and transport waste must be suitable for the requirements of the task. Some areas may have legislation outlining specific requirements (Government of Canada, 2008; HRM, 1999;NSE, 2009; USEPA, 2005). It is therefore important that firms and organizations ensure they are in compliance with any government (federal, provincial and municipal) which may be in effect.

Table 5: Commonly used collection equipment (Adopted from CCME, 1996, p. 33

Type	Volume Capacity	Approximate Costs*	Advantages	Disadvantages	Examples from Dalhousie University (2010-2011)
Collection Containers	Various sizes and volumes	$10-15	Can be deployed in various locations, ranging from individual workstations to hallways and other small areas. Can be used to encourage proper sorting	Stores small amounts of waste Garbage receptacles can encourage improper sorting	 
Public Sorting Units & Multiple Bin Stations	0.35 yd^3 x (2 or more)	Indoor: $300-3000 Outdoor: $900-1500	Durable Aesthetically pleasing Encourages proper sorting	Larger size can prohibit range of suitable locations	
Waste Bins	~ 0.5 yd^3	$90-140	On wheels so they can be transported to central location Lid helps prevent contamination Holds larger volumes of waste	May require thorough cleaning when used for materials such as organics	

Carts & Tilt Trucks	~ 0.5 - 2 yd^3	5/8 yd^3: $475-600 (regular) $600-700 (heavy duty) 2 $yd^{3:}$ $950-1150 (regular) $1400-1600 (heavy duty)	On wheels allowing for easy transportation May hold large volumes of waste Good for collecting waste from smaller collection containers and bins	Not suitable for long term waste storage Can be difficult to remove heavy items from the bottom	
Loading Bins	~ 2 - 4 yd^3	(typically rented from a waste service provider) Range form $60-200 per week for the bins and $15-30 per pick up.	Holds larger quantities of waste May have wheels to allow for movement Can be fitted with locks and lids for outdoor use and controlled access	They require servicing by trucks and require large amounts of space May be too large for certain waste streams Illegal dumping can be problematic if bins are not equipped with proper lids and locks	
Roll Off Bins	Up to 40 yd^3	(typically rented from a waste service provider) Range from $100-150 per pick up	Holds large quantities of waste Suitable for short-term projects with large volumes of waste	Must be kept outdoors Requires servicing by specialized vehicles Not suitable for all waste types Illegal dumping can be problematic	

*Cost estimates obtained for ordering individual units. Customized features, shipping, and bulk ordering can drastically change equipment costs.

Processing Equipment

Processing equipment needs will vary considerably depending on the size of the firm and the nature of the waste being produced (Table 6). Processing equipment is useful for handling and storing large volumes of materials. By processing waste materials, the volume can be reduced significantly. This means that less frequent waste pickup is required, and more materials can be transported per shipment.

It is possible for certain waste streams to be compressed with balers and compactors to reduce their volume. Balers are used to create dense blocks of waste called bales. These bales can be sold to local area businesses which can use the bails as a resource in the manufacturing processes (UC Davis, n.d.). Compactors and densifiers can be used to compress materials such as cans into denser forms, while crushers can be used to break materials such as glass into significantly smaller pieces. These types of machines can be useful for reducing storage space requirements for certain materials (CCME, 1996). When examining the potential for collecting recyclable materials to sell back to the market, it can be useful to contact local area firms that are involved purchasing these materials to ensure they will accept the bale sizes and quantities your organization has to offer. Larger bales of materials often fetch a higher market price but the machinery to produce them will require more space to operate.

Table 6: Commonly used processing equipment (Adopted from CCME, 1996; UC Davis, n.d.)

Type	Function	Example
Vertical Baler	Vertical balers offer the benefit of occupying a small footprint of floor space and they produce bales which may be moved around on pallets. These types of bailers also offer the benefit of being able to process materials as they accumulate.	 (source: nexgenbalers.com)
Horizontal Baler	Horizontal balers require much more floor space to operate, and are designed to handle much larger capacities than horizontal balers. They produce much larger bales, called mill bales, which can sell for a higher price on the market and can make them more economical in the long-term if enough area is available for operation. The cost of these balers has fallen dramatically; from approximately $250,000 U.S in 1993 to ~$30,000 today (UC Davis, n.d.).	 (source: clydesdalerecyclingmachinery.co.uk)

Self Contained Compactor	Roll off bins can also be combined with compactors. This provides an opportunity for decreased service frequency by offering greater capacity than loading bins, while allowing for a reduction in the volume of waste being transported. It is estimated that compactors can condense refuse by an average of three to one (UC Davis, n.d.).	 (Source: marathonequipment.com)
Crusher	Crushers are used to crush glass into cullet, helping to maximize storage space. When crushers are used, materials must be kept separate if they are going to be sent to recyclers. Recycling companies will typically ask that the crushed glass contain only one cullet type (CCME, 1996).	 (Source: cpmfg.com)
Densifier	Densifiers are used to compact aluminum or steel cans into small dense units. When using a densifier to compact recyclable wastes, it is common for recycling companies to demand that the feedstock consist of similar materials. For example, steel cans are not typically accepted with aluminum cans (CCME, 1996).	 (Source: jddenterprise.com)

Hazardous Waste Equipment

The federal Transportation Dangerous Goods Regulations are the basis for hazardous waste management in Nova Scotia. Hazardous wastes are classified in the regulations and those which are listed must be labelled, packaged and handled according to the procedures outlined in the regulations. Hazardous wastes are divided into 9 different classes, and these classes of wastes are sub-categorized according to chemical and physical properties, concentrations and volumes (Government of Canada, 2008). A detailed account of all the equipment requirements of a hazardous waste management plan are beyond the scope of this literature review, however, the data is available online through Transport Canada's website (See Government of Canada, 2008).

Waste Service Providers

Larger organizations often require services from an external waste service provider. These companies are required to ensure that any bins they provide customers meet local area requirements. When contacting a commercial waste service provider, they will be able to provide customers with a range of potential options to suit their needs. Hiring a waste service provider will typically require forming a contract. There are some elements which need to be known in advance to ensure that an effective contract for both the waste service provider and the firm or organization requiring the services (UC Davis, n.d.). There are many different factors which can be negotiated in a contract including the frequency of collection, the equipment being used, the fees, volumes collected, and rates for different streams. It can be useful to conduct a waste characterization study before approaching external waste service providers to ensure that contract provisions will allow for implementation of the waste management strategy in a cost effective manner (CCME, 1996).

Contracts can have a variety of clauses including:

- **Termination for cause** allows for cancellation of a contract if a problem is recurring and not being fixed after repeated requests
- **Non-performance or failure to perform** offers sanctions for unexcused missed pick-ups, non-reported blocked bins and inadequate maintenance of bins and equipment. Sanctions can take form as verbal warnings, or financial penalties
- **Normal working hours** states which days and hours the vendor can provide service. Any special holidays or events (such as move in and move out week) should be included in this section.
- **Communication** can be required in some contracts. For larger organizations with frequent pick-ups, it is possible to have contractors provide the firm or organization with a two-way radio so that contact may be maintained with the service trucks on the property
- **Dedicated vehicles** can be stated in the contract, meaning that the truck arrives at the property empty or with a calculated net weight of the truck so an accurate weigh bill can be calculated
- Types of **collections** should be specified. Container types, waste streams and frequency of collection should be specifically stated
- The types and numbers of **containers** being used should be explicitly stated in the contract as well as a requirement to keep them clean, painted, and labelled properly and that maintenance be carried out within a certain period after a formal request is made
- **Collection sites** should be left clean. It is possible to specify what is to be done with excess matter that is left next to the bins.
- **Invoicing & reporting** can require weight tickets and monthly reports be provided to the organization. Point of service reports can include average weights of waste collected from individual locations over extended periods of time (UC Davis, n.d)

Signage and Labelling

Signage is a critical component to waste management systems. Signage helps inform the public about what materials are acceptable for recycling and which are not and it can also encourage participation in recycling programs (UC Davis, n.d.). In Nova Scotia, educational efforts are carried out at the provincial level by the Resource Recovery Fund Board (RRFB), and at the municipal level. The RRFB has created a signage system (Figure 6) that relies on both colours and shapes to educate the public on sorting waste into proper waste streams (RRFB, n.d. b).

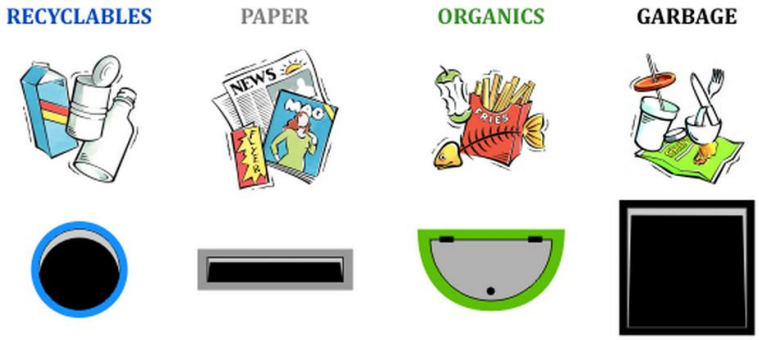


Figure 6: The colour coding, signage, and bin openings recommended by the RRFB (RRFB, n.d. b)

It is also possible for municipalities to create their own by-laws regarding signage (Figure 7). In HRM, by-law S-600 states that signage of sufficient size and number is required to provide occupants (customers or employees) with clear instructions for proper sorting of waste into its proper waste streams (HRM, 1999).

Figure 7: Signage and colour coding recommended by HRM (HRM, 2010)

Certain signs (ex. RRFB) with less text description may be better suited for more public spaces/higher traffic areas where people are less likely to read text and will make a source separation decision quickly while other signs (HRM) may be better suited for public areas that are contained and where staff have time to read the signs.

Costs

There are different layers of costs involved with waste management and they are grouped in tiers according to the probability of occurrence and where in the system they occur (Appendix D). There are 4 different tiers of costs:

- Tier 1: Usual and normal costs
- Tier 2: Hidden and indirect costs
- Tier 3: Future and long-term liability costs
- Tier 4: Less tangible costs (N. P. Cheremisinoff, 2003).

Usual and normal costs occur directly as a result of compliance measures. They include capital costs for equipment and the costs for operating equipment. Hidden and indirect costs occur as a result of things like carrying out monitoring, obtaining permits, reporting, and insurance premiums. Hidden and indirect costs can often be overlooked despite the fact that they to represent a significant cost to waste management and can play a major role in selecting and designing a waste management strategy. Future and long-term costs are difficult to plan and budget for due to uncertainties with predicting future events such as the effectiveness of the waste management strategy, changes to regulations and the risks associated with chosen equipment and technologies. The less tangible costs are the most difficult to quantify, but they generally occur as a result of poor environmental performance, despite the fact that the waste management system is generally in compliance with regulations. Examples may include site cleanup costs associated with the decommissioning or the sale of a facility. Generally, these costs will favour the prospect of pollution prevention and waste minimization because waste that is not generated in the first place will not pose a risk in the future (N. P. Cheremisinoff, 2003).

Human Resources

The success of any waste management plan will rely upon the cooperation of several different stakeholder groups. The expected roles and responsibilities of these groups must be clearly outlined so that they are made aware of the expectations placed upon them, and to allow for an element of accountability. Sustainable waste management differs for firms within ICI sector rather than waste management at the municipal scale due to the wide range of services being offered by the firms, and the unique waste streams they will have to deal with. This means that a wide range of stakeholders will invariably be involved with waste management (Schübeler et al., 1996; UC Davis, n.d.). Stakeholders will

need to be identified and taken into consideration, while some roles may need to be created to implement and oversee a proper waste management plan (Appendix E)

Evaluation

After a waste management plan has been developed and implemented, a monitoring program must be put in place. Monitoring is an essential component to the continued success and growth of the plan. Monitoring also allows the expected impacts of the strategy to be measured against actual changes, and this can inform future revisions of the management plan. Evaluation and monitoring is typically conducted through use of waste characterization studies, bills, and weight tickers. Regular waste audits should be scheduled at least annually, but optimally at any time significant fluctuations in the waste stream are expected to occur throughout the year. The results from monitoring will allow for the calculation of diversion rates, waste reduction, participation, and costs. The information obtained from regular audits can then be used to inform a revised waste management strategy (CCME, 1996).

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APPENDICES

Appendix A - Resources

There is a wide range of available tools, guides and manuals that can be used to help firms in the ICI sector develop and implement waste management goals, auditing procedures, and waste reduction plans. Below is an overview of some useful resources pertaining to recycling and waste reduction programs, auditing processes, and municipal solid waste management.

UC Davis - *College and University Waste reduction and Recycling Manual.*

The University of California, Davis (UC Davis) has created a comprehensive waste management guide that is designed for professionals seeking to implement a recycling/waste minimization program. Many of the areas associated with waste management are covered in detail in this manual including, but not limited to, the following: Solid waste auditing, quantifying progress, contracting language, and building management support. Although many of the examples used in this document apply specifically to universities, it was written in a way that makes it applicable to the ICI sector (UC Davis, n.d.). The manual is available for free at
http://sustainability.ucdavis.edu/local_resources/docs/recycling/manual.pdf

Canadian Council of Ministers of the Environment - *Waste audit users manual: A comprehensive guide to the waste audit process.*

This document contains a standardized waste audit and waste reduction framework that can be used by the ICI sector to help establish and achieve certain waste management goals. The auditing process described in this manual is comprehensive, outlining not only what should be done for each step of a proper waste audit, but also why it should be done. This is important because due to the differences between organizations in the ICI, some steps of the waste auditing procedure will not be required for certain firms, but it is important to understand the purpose of each stage and how they contribute o the final product (CCME, 1996). The manual is available for free at
http://www.ccme.ca/assets/pdf/pn_1210_e.pdf

U.S Environmental Protection Agency - *Decision-makers' guide to solid waste management, volume II*

This document has been developed for use by managers of municipal solid waste including local government officials, facility owners and regulatory agencies. The guide contains a comprehensive overview of many of the economic and technical considerations pertaining to municipal solid waste management which can help decision-makers consider how to best develop and implement an integrated solid waste management (USEPA, 1995). This manual provides a comprehensive overview of

the various aspects of municipal solid waste management and should be useful for most firms in the ICI sector. The manual is available for free at: http://www.epa.gov/osw/nonhaz/municipal/dmg2/

Resource Recovery Fund Board – *Waste Audit Guide*

A waste auditing guide has been created by the RRFB for use in Nova Scotia. The guide is particularly useful for organizations wishing to develop and implement an audit at their firm for the first time. It covers most of the basics and provides a clear understanding on how to get the job done along with a framework and worksheets for conducting the audit. The guide is great for firms looking to conduct their first audit, but it does not contain much on how to use audit results as part of a waste management plan or how to develop a long-term auditing strategy (RRFB, n.d. c). The guide is available for free from http://www.rrfb.com/pdfs/RRFB_Waste_Audit_Guide.pdf

Resource Recovery Fund Board - *Promotional Materials*

The RRFB has developed a variety of promotional materials that can be used by firms in the ICI sector to help get a grasp on waste management. Many of the materials produced by the RRFB focus on public education about waste management issues and provincial regulations (RRFB, 2008; n.d. b). These resources are limited in their ability to be comprehensive because they are designed for use at the provincial level and Municipal level legislation may stipulate different requirements than provincial legislation. A variety of educational and operational resources created by the RRFB are available for free at http://www.rrfb.com/pages/resources.html

Appendix B - Definitions

Baler: A machine used to compress recyclables into bundles to reduce volume. Balers are often used on paper, plastics, and corrugated cardboard (USEPA, 1995).

Construction and Demolition (C&D) Waste / Debris: Includes materials which are normally used in the construction of buildings, structures, roadways, walls and other landscaping material, and includes, but is not limited to, soil, asphalt, brick, mortar, drywall, plaster, cellulose, fibreglass fibres, gyproc, lumber, wood, asphalt shingles, and metals (Solid Waste-Resource Management Regulations, 1996).

Contamination: With respect to waste management, a contaminant is a material that has been placed into an incorrect waste stream; e.g., placing organic food waste into the paper stream.

Cubic Yard: A unit of volume commonly used for waste bins. One cubic yard is equal to approximately 765 litres.

Cullet: Clean, usually color-sorted, crushed glass used to make new glass products. (USEPA, 1995).

Hazardous Waste: Products which due to their nature and quantity, are potentially hazardous to human health and/or the environment and which require special disposal techniques to eliminate or reduce the hazard (Meakin, 1992). Hazardous wastes are classified in the *Transportation of Dangerous Goods Regulations.*

Municipal Solid Waste (MSW): Includes garbage, refuse, sludge, rubbish, tailings, debris, litter and other discarded materials resulting from residential, commercial, institutional and industrial activities which are commonly accepted at a municipal solid waste management facility, but excludes wastes from industrial activities regulated by an approval issued under the Nova Scotia *Environment Act* (Solid Waste-Resource Management Regulations, 1996).

Organics / Compostable Organic Material: In Nova Scotia, organic waste is composted and only compostable organic materials are included in the organic waste stream. Compostable organic materials are defined as vegetative matter, food processing waste, landscaping, garden and horticultural wastes, kitchen scraps, feed processing wastes, and other organic wastes which can be readily composted in composting facilities (Nova Scotia Environment, 2010).

Recovery: Conversion of waste to energy, generally through the combustion of processed or raw refuse to produce steam (USEPA, 1995).

Recycling: The process by which materials otherwise destined for disposal are collected, reprocessed, or remanufactured, and are reused (USEPA, 1995).

Refundables / Redeemable Beverage Containers: means an empty beverage container accepted by a depot for refund, or collected as part of a private or municipal collection program (Solid Waste-Resource Management Regulations, 1996).

Reuse: The use of a product more than once in its same form for the same purpose; e.g., a soft drink bottle is reused when it is returned to the bottling company for refilling (USEPA, 1995).

Source Reduction: The design, manufacture, acquisition, and reuse of materials so as to minimize the quantity and/or toxicity of waste produced. Source reduction prevents waste either by redesigning products or by otherwise changing societal patterns of consumption, use, and waste generation (USEPA, 1995).

Tipping Fee: A fee charged for the unloading or dumping of material at a waste processing facility (USEPA, 1995).

Waste Characterization/Waste Audit: A study undertaken to identify the source and quantity of waste streams and establish the mechanisms for waste minimization. Later audits evaluate the progress of waste minimization (Smith & Scott, 2005).

Universal Waste: Waste which poses significant environmental and safety hazards which cannot be processed with standard MSW, but does not pose the same level of risk as hazardous wastes.

Appendix C - Materials Banned From Disposal Sites in Nova Scotia

- Desktop, laptop, and notebook computers, including CPUs, Keyboards, mice, cables and other components
- Computer monitors
- Computer printers, including printers that have scanning or fax capabilities or both
- Televisions
- Redeemed beverage containers
- Corrugated cardboard
- Newsprint
- Used tires
- Automotive lead-acid batteries
- Leaf and yard waste
- Post-consumer paint products
- Ethylene glycol (automotive antifreeze)
- Steel/tin food containers
- Glass food containers
- #2 HDPE non-hazardous containers (ice cream containers, plastic jugs, detergent bottles, etc.)
- Low density polyethylene bags and packaging
- Compostable organic material (food waste, yard waste, soiled and non-recyclable paper

(List copied from http://www.gov.ns.ca/nse/waste/banned.asp)

Appendix D - Different Tiers of Waste Management Costs

Table 7: The different tiers of costs associated with waste management (N. P. Cheremisinoff, 2003)

Tier 1 – Usual and normal costs	Tier 2 – Hidden and indirect costs	Tier 3 – Future and long-term liability costs	Tier 4 – Less tangible costs
• Labor	• Monitoring costs	• Medical claims from injured workers	• Negative consumer response
• Energy	• Permitting & renewal fees	• On-site remediation	• Negative investor confidence
• Raw materials	• Environmental impact assessments	• Off-site remediation	• Long-term cleanup
• Pollution / waste fees	• Environmental transformation costs	• Inflation	• Lending institutions rescind or refuse favourable lines of credit
• Permits	• Legal fees	• Litigation fees	
• Equipment costs	• Service agreements	• More stringent compliance requirements	• Insurance premiums rise
• Site preparation	• Health and safety assessments	• Property devaluation	• Become a target for inspections
• Training	• Replacement costs		
• Monitoring	• Reporting & recordkeeping		
• System modifications	• Insurance premiums		
• Transport & Disposal	• Inspections		
• OM&R costs			

Appendix E - Stakeholders typically involved with a waste management strategy

Table 8 : Stakeholders typically involved with a waste management strategy

Solid waste manager / Recycling coordinator[1]	The solid-waste manager is responsible for overseeing the management of waste for the firm. In most cases, this person will be the representative for the firm with respect to waste management activities. In larger organizations, an additional recycling coordinator may be required to oversee recycling programs and carry out educational programs. If both positions exist for a firm, they will need to coordinate efforts and work together to form long-term plans.
Vendors[1]	Multi-use buildings which house several different businesses will need to coordinate efforts with these businesses. Problems with contamination, special pickup requirements, high and low traffic areas, and regular waste tonnage reports should be coordinated between the organizations.
Custodial staff[1]	Custodians play an active role in waste management programs. They are often responsible for collecting waste from indoor collection bins and bringing them to centralized containers. Any changes to waste management collection practices should be coordinated with custodial management and the custodians. Custodians can also be an important source of information in developing the plan. They are often aware of problematic areas, successful changes, and special events which require special considerations and can be helpful when reorganizing collection locations and schedules.
Contracts officer[1]	Most firms require the services of an external waste service provider. It is important to keep this person informed of the specific requirements of the plan and ensure that the necessary provisions are included in the final agreement. The contracts officer can also address other issues by including provisions in renovation and construction projects and vendor agreements (eg. Companies providing vending machines must help with costs for disposal and recycling, provide bins, or switch plastic bottles for aluminum cans).
Architects, engineers, planners[1,2]	Any new construction or renovation projects should make considerations for waste management. This includes ensuring that loading docks and central collection locations have sufficient space, and proper sorting stations have ample area to be deployed with adequate buffer zones.
Administrators / Management[1]	Any waste management plan which requires change will need to be supported by management and administration. Public encouragement and support for new policies and operating procedures are crucial.
High-volume generators[1]	Certain areas within larger firms, particularly those with multiple vendors and businesses within a single complex, may be faced with high-volume generators. Identify these groups and work with them to help improve waste minimization and diversion.
Police/Security[1]	Vandalism of containers, theft of valuable recyclables, and illegal dumping can all have negative economic impacts on a business, and on a successful waste management plan. Work with police and security to devise strategies for crime prevention; help determine ideal locations for bins and containers, and to help identify problematic areas. Private security should be informed that these issues are a concern for the organization and of what steps to take if problems occur.
Fire	Any changes to waste management must be in compliance with fire codes and regulations. If there are doubts or concerns as to whether new equipment will be in compliance, contact the relevant authorities.
Environmental/Occupational Health and Safety	A waste management plan should include a health and safety component which identifies officers which are responsible for training staff on collection procedures and outline what is to be done with hazardous materials that end up in the waste stream.
Municipal waste education officers	Municipal education officers can provide valuable feedback and advice when designing a waste management plan. They can share educational resources, help develop and education plan, and help determine what kind of services are required from waste service providers.
General Public & Service Users (including staff and volunteers) [1]	For many firms, the general public will be required to participate with the waste management plan. Their role will be to practice proper source separation and reduction practices[2] such as bringing a reusable coffee mug. Educational programs, signage and labelling should be designed to help the public understand their role within the firms waste management plan.

1. (UC Davis, n.d.)

2. (Schübeler, Wehrle, & Christen, 1996)