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Hazardous Waste Management: Alternatives for the University of Manitoba

by

Kelly Rusk

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In Partial Fulfillment
Of The Requirements For The Degree
Master of Natural Resource Management

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Hazardous Waste Management: Alternatives for the University of Manitoba

By

Mr. Kelly Rusk

A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfilment of the requirements of the degree of Master of Natural Resources Management.

ABSTRACT

For reasons such as, the protection of public health, the environment and limiting liability, proper hazardous waste management has become increasingly important in all sectors of society. The University of Manitoba Environmental Health and Safety Office has determined that an improved hazardous waste management program is in the best interest of University Faculty, Students and Staff. As a result, this study was initiated with the purpose of identifying alternatives for improving the hazardous waste management program at the University. The specific objectives included: categorization of the various hazardous waste streams at the University; identification of new management options for those wastes; recommendations of methods to manage at least the high quantity waste streams; and, the development of a management protocol for on-site management of hazardous wastes. The methods used in this study included: a review of related literature; interviews with representatives from eleven Canadian and nine American universities; and, analysis of the existing hazardous waste database.

Presently the University of Manitoba Safety Office receives approximately four tons of hazardous waste every year from various generators. This amount of waste results in disposal costs of approximately fifty thousand dollars per year. This cost is being reduced as a result of the Safety Office implementing on-site packaging of compatible wastes before they are sent for off-site treatment and disposal. While this

system is functioning well there are, however, still a number of concerns about the ability of the Safety Office to implement management options to reduce, reuse or recycle the hazardous waste currently being generated at the University. As well, there is concern that all hazardous waste generators are not reporting to the Safety Office.

Interviews with hazardous waste managers at several universities identified methods and procedures that they found useful for managing university hazardous waste. These included methods to educate generators to involve them in the management of the waste they produce, as well as ways of using computer systems for tracking and reporting on generation activity. Although not extensively used at this time, the use of centralized purchasing systems and charge-back programs were also identified as important steps to an effective management program. A number of options for minimizing waste requiring off-site disposal were also identified during the interviews, such as substitution for non-hazardous materials, improved laboratory practices, lower grade reuse of waste solvent, and neutralization of waste acids and bases.

From this research several recommendations were identified for improving the University of Manitoba hazardous waste program. A number of the recommendations are aimed at moving away from end of pipe management. These include: the development of waste minimization bulletins and guidebooks for generators; educational seminars on hazardous waste issues; a hazardous waste audit; and, a feasibility study on the implementation of a charge-back system. Additional recommendations involve expanded use of the computer based tracking system and techniques for reducing the amount of hazardous waste requiring disposal.

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Chapter 1

Background

1.1 Preamble

This document has been prepared as part of the commitment of the University of Manitoba's Environmental Health and Safety Office to developing a more structured method of hazardous waste management through identifying alternatives and/or less expensive management techniques.

This project was funded through the University of Manitoba Program Development Fund. It was identified by the Environmental Health and Safety Office and carried out as a Practicum leading to a Master's degree in Natural Resource Management.

1.2 Background

Hazardous wastes are generally thought of as those wastes that pose a risk to human health and/or the environment and require special disposal techniques to make them harmless or less dangerous (Environment Canada, 1991 -see Chapter 2). Improper or inadequate management of hazardous waste can result in contamination of air, water and land resources, and pose a potential threat to human health. The potentially dangerous characteristics of hazardous waste include; ignitability, corrosiveness, reactivity, and toxicity (EPA, 1990, Quinn, 1985).

Hazardous wastes can be properly managed through a number of techniques, including: reduction, reuse, recycling, recovery, treatment to reduce quantity and/or toxicity, and secure disposal (MHWMC, 1994). These techniques are listed in a prioritized hierarchy, with reduction being the most desirable method and secure disposal being the final option.

In the past, many hazardous wastes were disposed of through the sewer system or sent to domestic waste landfill sites for burial. More recently, through increased environmental responsibility, accountability, and government legislation, many of these previous disposal practices are no longer permitted or severely restricted. This has in part resulted in it being more difficult and expensive to properly manage and dispose of these wastes (Higgins, 1989). Additionally, those generating and managing hazardous waste want to ensure they limit legal liability to avoid future actions that may be taken against them if contamination results from improper disposal. Thus, it has become increasingly important to manage these wastes responsibly. This has resulted in a shift in emphasis toward reducing the amount and/or toxicity of hazardous waste that ultimately requires disposal.

Beyond avoiding liability there are also several benefits to individual waste generators through developing a hazardous waste management program. At a minimum these include, a reduction in disposal costs, protection of public health and protection of the environment (Lorton, 1988).

The University of Manitoba generates a wide variety of hazardous wastes which cannot be safely handled by municipal sewers or ordinary solid waste disposal services. Despite the variety of wastes generated, the University is considered a small quantity generator based on the volume of hazardous waste produced. In recent years hazardous waste disposal has resulted in an annual cost of approximately 50,000 dollars to the University (Gusdal, 1995). These wastes are generated as a result of education, research, and support activities at both the Fort Garry Campus and the Bannantyne Campus. The Fort Garry Campus is located adjacent to the Red River in the south end of Winnipeg. It serves greater than 20,000 students, offering courses in Arts, Science, Engineering, Agriculture and others. The Bannantyne Campus is located in central Winnipeg adjacent to the Health Sciences Centre. Health sciences research and eductaion activities are carried out there. The Environmental Health and Safety Office is responsible for receiving, storing, and properly disposing of these wastes.

The Safety Office has compiled a computerized database containing information about the various types of hazardous wastes collected and commercially disposed of by the University since 1989. This database contains information about the type and quantity of wastes produced, and also source and disposal information. As well, the database can provide sorted listings of the wastes based on various criteria. One portion of the database contains greater than 4800 entries consisting of more than 3400 different hazardous wastes that were picked up by the Safety Office between September 1993 and July 1994. Any hazardous waste item received by the Safety Office is considered a different hazardous waste if the contents are not identical to another.

1.3 Problem Statement

The amount of hazardous waste being received by the University of Manitoba Environmental Health and Safety Office is increasing each year. This increase in hazardous waste, coupled with the potential for new regulations reducing the types of materials that can be sent to domestic waste landfills, could lead to higher disposal costs. There is a need to examine the hazardous wastes being received and determine if the amount and/or toxicity of those wastes can be reduced.

1.4 Objectives

The purpose of this project is to analyze and organize existing data on the hazardous waste streams generated at the University of Manitoba in order to identify new management options that might assist the Safety Office in achieving their previously stated goals.

Based on this, the specific objectives for this project include the following:

1. To categorize the various hazardous waste streams at the University.
2. To identify and develop options for reducing, reusing, recycling and disposing of the products in these waste streams.
3. To recommend methods to manage and reduce at least the high quantity hazardous waste streams.
4. To develop a management protocol for hazardous waste management decision making for the on-site management of hazardous wastes.

For the purposes of this study a management protocol is defined as a decision making process for the proper internal management of hazardous wastes. It includes procedures for the classifying, handling, receiving and documenting of hazardous waste by the generators and the receivers.

1.5 Methods

Several techniques were used to gather material for this study. The methods used included: a review of related literature, interviews with representatives involved in hazardous waste management, and computer analysis of the University of Manitoba Safety Office hazardous waste database.

1.5.1 Literature Review

The first step in this study involved a review of related hazardous waste management literature. This was used to provide information and insight into the current state of hazardous waste management. Information examined covered topics including, but not limited to: hazardous waste definitions, classification of hazardous waste, management practices at research and educational institutions and in industry, and alternative management options for the reduction of hazardous waste.

Where literature existed, specific information about on-site hazardous waste management relating to the university setting was used. Literature was gathered through, the University of Manitoba library system, the Manitoba Hazardous Waste Management Corporation, provincial and federal government publications. Additional information was obtained from some of the participants in the interview portion of this research. "Gopher" sites on the internet also provided valuable information about hazardous waste management.

1.5.2 Interviews

Structured interviews were conducted with various persons involved in the management of hazardous waste at 20 universities located in Canada and the United States (See appendix 5). Initial participants in the interviews were identified from their association with universities known to use alternative hazardous waste management methods as identified in the literature. Additional participants were identified during the initial interviews. The interviews were conducted between February and April 1995.

Participants in the interviews were the people responsible for the day-to-day operation of the universities hazardous waste programs. The objectives of the interviews were: to provide insight on hazardous waste management programs at universities in various jurisdictions; to provide additional information on current methods and technologies that could be applied to identified hazardous waste streams at the University of Manitoba; and to provide information on the use of computer databases and their application to hazardous waste management in university settings. During the interviews participants were also requested to send information about their respective hazardous waste management programs, including procedures, protocol and computer tracking systems.

Informal personal communications were also conducted with several hazardous waste generators at the University of Manitoba to gather information about the effectiveness of the hazardous waste collection system and also to identify their views about changes to the system.

1.5.3 Computer Analysis

Analysis of the computer database created by the Safety Office at the University of Manitoba was carried out in order to assist in the identification and categorization of hazardous waste streams generated by the University. Information in the database was examined with the aid of computer software designed for manipulating data. The data was examined to establish volumes of waste streams and to identify where alternative management techniques could be applied.

1.5.4 Application to High Quantity Waste Stream

The information gathered as outlined above, particularly related to high quantity waste streams, was used in the development of a protocol system for waste management decision making.

1.6 Importance of Study

Improper management and disposal of hazardous wastes can have serious implications to the environment, health and safety, reputation and budgets. In addition, improper management of hazardous waste represents a significant financial cost to the University of Manitoba. It is likely that the improper disposal of hazardous waste will represent a significantly larger cost in the future. It also appears that, recent legal decisions and federal and provincial legislation, have increased liability concerns. The result has been that a proactive approach to dealing with environmental contamination might prevent the future costs of clean-up and rehabilitation. By undertaking this project the University of Manitoba is consistent with the general trends in dealing with this issue as well as showing that it is providing stewardship of the waste generated by its activities.

1.7 Scope of Study

This study examined only the hazardous wastes generated at the University of

Manitoba through its educational and research activities and support services. Non-hazardous waste streams (ie. those not defined as hazardous wastes in Chapter 2) were not included in the study. This study assumed that all hazardous wastes currently generated at the University of Manitoba are handled by the Safety Office and are accounted for in the database. This study excuses unreported and improperly disposed hazardous waste.

As well, it was assumed that the section of the database from September 1993 to July 1994 included all hazardous wastes generated at the University during that period. It is recognized that a potential for many more hazardous waste types exist in an institutional setting. Finally, this study did not examine the quality and or economics of disposal techniques and options utilized by commercial disposal companies contracted to handle the disposal of the hazardous wastes generated by the University of Manitoba. This issue should be addressed as part of a hazardous waste management program.

1.8 Organization of Study

This study is organized into 6 chapters. Following the introductory chapter (Chapter 1), is a review of related literature (Chapter 2). An exploration of the present system of hazardous waste management at the University of Manitoba is the subject of Chapter 3. The results of several interviews regarding hazardous waste management at other universities in Canada and the United States are contained in

Chapter 4. Chapter 5 contains a discussion of options and alternatives available to the University of Manitoba. The study is concluded with details on recommendations and concluding remarks (Chapter 6).

Chapter 2

Review of Related Literature

2.1 Definition of Hazardous Waste

Although difficult to define, increasing regulatory control makes it more important to develop a suitable and widely accepted definition of hazardous waste. The Federal Task Force in Canada on Hazardous Waste Definition agreed on the following definitions (Glenn et al, 1988, Meakin, 1992);

waste -

> any substance for which the owner/generator has no further use and which he discards.

hazardous waste -

> those wastes 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.

This definition of hazardous waste is not a regulatory definition, since the waste included or excluded as hazardous is open to interpretation. Legislation generally includes definitions that list specific types of hazardous wastes. For example, the federal Transportation of Dangerous Goods Act and Manitoba's Dangerous Goods Handling and Transportation Act indicate that a hazardous waste is a substance that is listed in the regulations (e.g. asbestos, benzene), or if not listed in the regulations, conforms to criteria specified in the regulations (e.g. if a substance is a leachable toxic substance at a specified concentration in the waste extract such as lead at 5.0 mg/L) (Manitoba Environment, 1993, MHWMC, 1994).

Under the Canadian Environmental Protection Act, the definition of hazardous waste is being expanded to include hazardous wastes as listed in the Basel Convention under Annex I and III as well as those wastes as listed in the Transportation of Dangerous Goods Act (Meakin, 1992).

In the United States, the legal definition of hazardous wastes under the 1976 Resource Conservation and Recovery Act (RCRA) is any waste that is found under one of four EPA lists or exhibits certain hazardous characteristics, including: (EPA, 1990, University of Wisconsin, 1995)

ignitable - flash point less than 60°C
corrosive - pH less than 2 or greater than 12.5
reactive - explosive or reacts violently with air or water and some chemicals like cyanides and sulfides that may produce toxic gases
toxic - toxic by EPA leach test method. If a waste is found to contain high concentrations of heavy metals or specific pesticides
toxic chemicals - chemicals on specific lists that are carcinogens, mutagens, teratogens or toxic compounds.

There is, however, an indication that the EPA is moving away from characteristic based definitions of hazardous waste and moving toward risk based definitions as well as hazardous wastes listed under the Basel convention (Cooke 1995, pers comm).

The Basel Convention has ratified an international definition of hazardous wastes which has been agreed to by 68 contracting parties as of June 1994. For the purposes of this convention, hazardous wastes are those wastes contained in Annex I or having the UN class code characteristics listed in Annex III or any wastes considered hazardous by the country of import, export or transit. The purpose of the Basel Convention was to control transboundary movements of hazardous waste. The Basel Convention has also been significant in determining national definitions and classification systems among ratifying parties.

There are also a number of related definitions that help to determine what may be considered hazardous wastes. For example Andres 1988, defines hazardous materials as, "those materials that are flammable, explosive, corrosive, toxic or otherwise potentially hazardous to people or the environment". The Manitoba Dangerous Goods Handling and Transportation Act also provides some additional definitions;

contaminant -

any solid, liquid, gas, waste, odour, radiation or any combination thereof that (I) is foreign to or in excess of the natural constituents of the environment, or (ii) affects the natural, physical, chemical or biological quality of the environment, or (iii) is or is likely to be injurious or damaging to the health or safety of a person.

dangerous goods -

any product, substance or organism designated in the regulations, or conforming with the criteria set out in the regulations or in any regulation adopted in accordance with this Act, and includes hazardous waste.(Glenn et al, 1988)

The criteria governing the regulatory compliance for the University of Manitoba hazardous waste are the regulations of the Manitoba Dangerous Goods Handling and Transportation Act. Therefore, for the purposes of this study hazardous wastes are those substances listed in the regulations of the Manitoba Dangerous Goods Handling and Transportation Act, or conforming to the criteria listed in the regulations (specifically, MR 172/85 and MR 282/87).

2.2 Classification of Hazardous Wastes

Hazardous wastes may be classified or categorized in several different ways. A classification system for hazardous wastes could be based on regulations such as in the Manitoba Dangerous Goods Handling and Transportation Act. In Manitoba the basic division of the various hazardous wastes and dangerous goods follows the United Nations classification system recognized world-wide. This is also the system as set out in the Canadian Transportation of Dangerous Goods Act (TDG). The divisions consist of nine basic classes of hazardous wastes, including: (Manitoba Environment 1993)

Class 1	Explosives
Class 2	Gases: compressed, deeply refrigerated, liquified or dissolved under pressure
Class 3	Flammable and combustible liquids
Class 4	Flammable solids: substances liable to spontaneous combustion; substances that on contact with water emit flammable gases
Class 5	Oxidizing substances; organic peroxides
Class 6	Poisonous (toxic) and infectious substances
Class 7	Radioactive materials

Class 8	Corrosives
Class 9	Miscellaneous products, substances or organisms dangerous to life, health, property, or the environment

Most of these classes are subdivided according to further characteristics (see Appendix 1), and some materials may be under more than one category. This classification system is used by industry to provide for packing requirements, labelling, tracking, safety marking, material compatibility and other regulatory controls (Glenn et al, 1988). This system also provides a tracking system for transportation of hazardous wastes. Generators are required to fill out a manifest for hazardous waste transport according to the classifications (Manitoba Environment, 1993).

A more detailed waste categorization system developed at the University of California at Davis (UCD) is based on the types of materials going into landfills (Glenn et al, 1988). The UCD system (see Appendix 2) consists of 95 categories of wastes that fall under inorganics, organics, sludges and miscellaneous. This classification system is considered a waste manager's system and has been adapted for use in Ontario and also by the Manitoba Hazardous Waste Management Corporation (MHWMC). The system is widely used by waste managers since it more closely follows the management options available. The categories are based on the type of process generating the waste rather than criteria for safe transportation. For example, category (13) contains metal-finishing solutions. This allows management options to be examined for the production phase rather than after the waste is generated.

Classification systems can be developed and used in various ways. For example, classification systems could be used to categorize wastes into waste streams based on, waste reduction techniques, treatment, degree of hazard, storage and/or disposal methods. One objective of this study was to categorize the various waste streams at the University since different classification systems may stimulate ideas for the reduction of those hazardous waste streams. The basis for the use of different classification systems was also a question asked during the interviews, and is further considered in Chapter 4.

2.3 Hazardous Waste Management

"Hazardous waste management" includes all activities associated with the transportation, treatment, handling, reduction, elimination, recycle, recovery and disposal of materials deemed to be hazardous waste (CCME 1988). Since hazardous wastes may retain their harmful properties over a long period of time it is important to minimize the amount of hazardous wastes requiring disposal (CCME 1991). A "hazardous waste management program" could include such steps as: a complete inventory of chemical usage and waste generation practices, listing of storage and disposal practices and requirements and, identification of wastes for potential reduction, elimination, recycling, recovery and reuse (Glenn et al, 1988). In addition, due diligence activities such as monitoring, record keeping, and reporting would be included.

An important aspect of hazardous waste management is a hazardous waste minimization program. Waste minimization is recognized as a priority management activity in the Canadian Environmental Protection Act. This recognition arises from the fact that it is more desirable to not create waste than to attempt to manage it (recycle, treat, dispose) after generation (Environment Canada, 1994). As well, it is understood that waste minimization (and pollution prevention) is more cost effective, socially acceptable, and better able to reduce the risk of harm to human health and the environment than pollution control (Environment Canada, 1994).

Hazardous waste minimization can be thought of as anything that reduces the use of hazardous waste treatment, storage and disposal facilities by decreasing the quantity or toxicity of the waste (Higgins 1989). Waste minimization may involve the reduction in quantity of waste through good housekeeping practices or by using concentration technology (Laughlin and Varangu 1988, NRC 1985). An effective waste minimization program can reduce costs, liabilities, and regulatory concerns of hazardous waste management, while potentially enhancing efficiency and community relations (EPA, 1990).

In undertaking a hazardous waste minimization program there is a hierarchy of options that are to be followed, including:

1. Waste Reduction - eliminate wastes and/or minimize volume and toxicity
2. Waste Reuse - see if others can use it
3. Waste Recycle - reclaim as much as possible
4. Resource Recovery - recovering beneficial use from waste
5. Waste Treatment - treat to destroy or make safe
6. Waste Disposal - disposal of residues

(Laughlin and Varangu 1988, EPA, 1990, MHWMC, 1994).

The first three steps of this hierarchy are considered waste minimization. The techniques used in these categories of waste minimization may overlap depending on the situation and types of waste streams encountered. These techniques of waste minimization generally apply to all hazardous waste streams. Hazardous waste minimization programs are, however, site-specific. For example, the majority of generators of hazardous waste produce consistent, predictable waste streams. It may be fairly easy therefore for an industry to identify and implement waste minimization techniques since they can be certain of the types and quantities of hazardous wastes they produce.

However, due to the variety and small quantity of wastes they produce, research and educational institutions have different waste management problems and resources available to deal with them than most industrial waste generators (EPA, 1990). This makes it difficult for research and educational institutions to justify the costs of implementing some waste minimization techniques. For example, the University of Victoria at one time produced a large quantity of solvent waste that they recycled. However, the use of solvents, such as formaldehyde, has dropped so the cost effectiveness of this program is now in question. This does not rule out the fact that there may be some waste streams at universities that are consistent and predictable, such as oil from vehicle maintenance.

A large number of examples from industry clearly exemplify the application of the above categories. In the case of waste reduction, an example of an inventory control procedure is the "just-in-time" (JIT) concept. This is a management system which results in no intermediate storage of raw materials and completed product. Because there is no storage of raw materials or product, there is no chance of outdated materials requiring disposal. With JIT the 3M Company reduced waste generation by 25% to 65% (Hunt, 1991). Direct reuse of solvents for cleaning is a common example of waste reuse. An example of waste recycling is given in the case of a California printer of newspaper advertising. Various waste inks are blended and black toner is added to make black ink (Lorton, 1988). The recovery of silver from photofinishing chemicals is a common and successful form of resource recovery. The silver can be sold to a recycler to pay for the recovery unit (Lorton, 1988).

2.4 Hazardous Waste at Research and Educational Institutions

Universities and research laboratories can produce a wide variety of hazardous wastes which cannot be safely handled by municipal sewers or regular disposal services. These wastes come from disposal of used, spent, spilled or outdated chemicals and associated products. Additional wastes are generated through support services such as maintenance. In general, industrial operations produce only a very small number of hazardous wastes of fairly uniform composition. University research and teaching laboratories produce less hazardous waste by amount, however, its toxicity may be greater (Glenn et al, 1988). Universities may produce hundreds or thousands of different hazardous wastes in small quantities that are more dangerous if improperly disposed of (or perhaps less well studied) than the wastes produced in industrial operations (Dalhousie University, 1995). In addition, the management structure of universities tends to be more decentralized than that of the typical business. This makes tracking of hazardous materials more difficult (EPA, 1990).

Laboratory wastes from universities are typically generated in quantities of less than one gallon per occurrence with research laboratories generating more waste than teaching laboratories. The types of waste streams produced by research laboratories include, inorganic acids and bases, organic solvents, metals, unused chemicals, reaction products from experiments and some photographic waste (EPA, 1990). Other generators at universities may include, art departments, printing, photography and support and maintenance departments. The type of waste produced from art departments include, paints, thinners, solvents and heavy metals. Photography generates waste containing silver and developing solutions. Maintenance operations can generate waste from vehicle maintenance, construction, equipment repair, drycleaning and laundry, and metal manufacturing, creating waste solvents, petroleum products, parts cleaners, paint wastes, pesticides, and water treatment chemicals, to name a few (EPA, 1990). The EPA in the United States actually publishes information on wastes produced by these activities as well as the regulations to be followed (EPA, 1990).

The most common management technique for hazardous wastes from educational institutions is off-site disposal, after they have been lab-packed in drums or bulked with compatible liquids in drums. Lab-packs are drums filled with individual containers of hazardous waste that can all be disposed by the same method. These containers are then handled by the disposal contractor at various off-site locations.

2.5 Hazardous Waste Minimization Techniques at Research and Educational Institutions

This section examines the various methods and techniques available to minimize hazardous waste as set out in the hierarchy in section 2.3. The waste minimization methods outlined for research and educational institutions generally fall into three general categories: improved material management practices, improved laboratory practices and improved waste generation practices in non laboratory settings(EPA, 1990). Improved practices in non laboratory settings include, art, maintenance, groundskeeping, photofinishing, etc.

2.5.1 Hazardous Waste Reduction

Hazardous waste reduction refers to the elimination or the drastic reduction of wastes produced (NRC, 1985). It is more desirable to stop waste production than to attempt management (through recycling, treatment and disposal) after generation of the wastes (Environment Canada, 1994). It may be possible to do this through several of the following methods. Elimination of wastes is likely the most effective strategy in a university setting.

2.5.1.1 Improved Material Management Practices

Many options for improved material management have been identified for research and educational institutions to reduce chemical and other hazardous material usage and therefore reduce disposal costs.

One method involves the establishment of a centralized purchasing system which can be used to implement changes in materials purchasing and control to consider waste management (Higgins, 1989, Hunt, 1990, EPA, 1990). There are several ways that a centralized purchasing system can reduce hazardous waste: the system can monitor requests of materials and encourage the sharing of chemicals between users, reducing the number and amounts of products used; materials can be purchased based on use and not unit-cost savings of larger containers. If larger containers of chemicals reach the end of their shelf life before use, the savings will be lost due to disposal costs (EPA, 1990).

Establishment of an inventory control program would provide a system to track hazardous materials from purchase to disposal. Additionally, information on high volume users and locations of material can be recorded to ensure proper stock rotation takes place. This information can help staff determine where waste reduction options need to be examined.

2.5.1.2 Laboratory Practices

Changes in laboratory practices may also result in reduced hazardous waste production. Several methods exist for the reduction of laboratory waste (EPA, 1990, UIUC, 1995). For example the substitution of less toxic or non-toxic materials where possible is now a common practice. The Chemical Waste Management Section of the University of Illinois at Urbana-Champaign (UIUC) has developed a list of common chemical substitutions from their study on laboratory waste minimization opportunities. The following table (Table 2.1) has been taken from the UIUC Waste Minimization Bulletin - No.1 (1995). These substitutions may not be possible in all cases.

In addition to this listing, chromic acid solutions as well as mercury and it's compounds are additional materials that should be substituted (University of

Table 2.1: Potential laboratory chemical substitutions (from University of Illinois at Urbana-Champaign Waste Minimization Bulletin No. 1)

Original Material	**Substitute**	**Comments**
Acetamide	Stearic acid	In phase change and freezing point depression
Benzene	Alcohol	
Benzoyl peroxide	Lauryl peroxide	When used as a polymer catalyst
Chloroform	1,1,1-trichloroethane	
Carbon tetrachloride	Cyclohexane	In test for halide ions
Carbon tetrachloride	1,1,1-trichloroethane 1,1,2-trichlorotrifluoroethane	
Formaldehyde	Formaltermate Ethanol	For storage of biological specimens
Formalin	See Formaldehyde	For storage of biological specimens
Halogenated Solvents	Non-halogenated solvents	In parts washing or other solvent processes
Sodium dichromate	Sodium hypochlorite	
Sulfide ion	Hydroxide ion	In analysis of heavy metals
Toluene	Simple alcohols and ketones	
Xylene	Simple alcohols and ketones	
Xylene/Toluene based liquid scintillation cocktails	Non-hazardous proprietary liquid scintillation cocktails	In radioactive tracer studies
Mercury salts	Mercury free catalysts	Kjeldahl digests

Wisconsin, 1994). There are nonhazardous and less hazardous alternatives to using chromic acid for cleaning. One common form of mercury waste is broken thermometers. Substitutes for mercury thermometers include, alcohol thermometers and thermocouples (University of Wisconsin, 1994, UIUC, 1995).

The quantity of hazardous waste may also be reduced through the use of microtechnology, including the use of microscale equipment and highly sensitive analytical equipment (Glenn et al, 1988, EPA, 1990). This may allow chemical reactions to be carried out with smaller amounts of chemicals. Computer simulation and modelling may also be an option for replacing laboratories using hazardous materials.

Proper handling of laboratory hazardous wastes is important for reducing the variety and amount of waste and the cost of disposal (Goldman et al, 1986, Hunt and Schecter, 1988, EPA, 1990, Hunt, 1990). As well, by segregating wastes at the source, non-hazardous wastes will be prevented from becoming hazardous wastes, reducing the volume of waste and the cost of disposal. Segregating recyclable hazardous waste from non-recyclable hazardous waste to reduce the need for disposal is also an important management step. In addition, by ensuring that different hazardous waste streams are kept separate, disposal costs may be reduced. For example, disposal of halogenated solvents may cost significantly more than disposal of non-halogenated solvents.

Concentration is another method for reducing the volume of hazardous waste (Hunt and Schecter, 1988). This usually involves a physical treatment technique, such as filtering, that removes the non-hazardous portion of the waste, such as water. Concentration may also be useful in increasing the potential for recycling or reusing.

2.5.1.3 Practices in Non Laboratory Settings

Improved practices in areas other than university laboratories may also be implemented to reduce or eliminate the amount of hazardous waste requiring management. Some examples include: substituting water based paints for oil based paints in art and maintenance operations; modifying painting techniques to reduce paint use; increasing the use of biological pest control; collecting waste oil and solvents for recycling; recovering silver from photographic wastes; and substituting biodegradable cleaners for use by maintenance and cleaning staff.

Educating generators of hazardous waste about hazardous waste minimization can also affect the amount of waste produced. The University of Illinois at Urbana-Champaign publishes and distributes a series of waste minimization articles and also carries out mandatory training for waste generators.

2.5.2 Waste Reuse

Waste reuse involves the direct reuse of the waste stream, as is, or with minor modification (NRC, 1985). This may involve the reuse of the waste by the generator, or by other users, on-site or off-site. Quite often the wastes can be used in a secondary or lower grade function. For example, waste solvents from one generator can be used to clean parts in the maintenance department of another. Reuse can help reduce disposal and raw material costs.

Waste exchanges exist throughout North America and are a fundamental component for off-site reuse (Krumme, 1992). Waste exchanges function by providing information on waste materials wanted and available. Waste exchanges may also actively try to match generators with users and ensure the transfer of waste materials (MWE, 1994). The Manitoba Waste Exchange provides computer links to other exchange groups in Canada, and also provides access to American exchange networks. In the Exchanger, the Manitoba Waste Exchange bulletin, listings are provided with information on materials available and material wanted, with a short description and quantity (MWE 1994). Common types of hazardous wastes exchanged include;

- organic chemicals,
- oils, fats and waxes,
- acids and alkalis,
- metals and metal sludge.

Most exchanged wastes are those with existing markets such as oils, solvents and acids. Markets are generally not created by the exchange (CCME, 1988).

2.5.3 Waste Recycling

Waste recycling involves the return of waste streams to their original use or some other use, through the application of unit processes (NRC, 1985). Examples of recycling include; newspaper recycling, waste oil re-refining, solvent distillation, recycling of plating solutions and recycling photofinishing chemicals. Recycling may be carried out on-site if the volume is enough to be cost-effective. Small generators of waste generally use off-site recyclers who utilize a number of generators to provide needed volumes. The recovered materials can be sold to the original generator or other companies (Goldman et al, 1986).

The most common hazardous waste stream recycled in a university setting is solvents. On-site distillation of waste solvents may provide a money-saving and environmentally sound option to contract disposal if the volumes of solvents are high enough for economical justification (Ashbrook and Klein-Banay, 1994). For most small quantity university generators on-site distillation is not economically viable. In these cases solvents may be kept segregated to enable off-site recycling to be done under contract. Some universities with chemistry or engineering laboratories may also be able to distil solvents in pilot projects for teaching and research.

The University of British Columbia, for example, has a fairly successful solvent recovery program. They provide a gas chromatograph analysis of the recycled solvent to show it's purity. In addition to reuse on campus, there are several non-university contracts for the recycled solvents (Alexander, pers comm).

The EPA indicates further, that waste types including batteries, waste oil, anti-freeze, and scrap metal may also be sent to off-site locations for recycling at a charge less than that of disposal (EPA, 1990).

2.5.4 Resource Recovery

Resource recovery involves the handling of a waste so that the useful portion of the waste is recovered for reuse (Ashbrook and Klein-Banay, 1995). Some materials, such as metals, can be recovered from waste streams for reuse or proper disposal (MHWMC, 1994). The recovery of silver from photographic chemicals may be carried out on-site or off-site through a contractor. Recovery of mercury and other metals from catalysts may also be done using chemical procedures (EPA, 1990). Some waste oils and solvents can be blended as fuel in certain facilities to recover the heat value (MHWMC, 1994, University of Wisconsin, 1994).

2.5.5 Waste Treatment

Treatment of hazardous waste can be, and often is, part of the reuse, recycling and recovery techniques of hazardous waste management. Treatment is also the final step before ultimate disposal of many hazardous waste residues. Waste treatment involves the conversions of hazardous waste to non-hazardous or less hazardous wastes. The types of treatments used include physical, chemical, biological, and thermal treatment. More than one of these treatments may be used on a particular waste stream (Meakin, 1992, NRC, 1985).

Physical treatments are used to separate solids from liquids by physical force or mechanical methods (e.g. a filter). This is done without chemically altering the form of the components and the resulting concentrated waste may require further chemical treatment. Chemical treatments neutralize, precipitate, oxidize or reduce the chemical component or cause the conversion of the liquid phase to a solid, vapour or altered liquid. Physical and chemical treatments are used to reduce volume, detoxify or stabilize the waste. A combined physical-chemical treatment of inorganic wastes is sometimes used to concentrate and then detoxify a waste stream (CCME, 1989, Meakin, 1992).

Biological treatments are sometimes used to degrade aqueous waste streams containing organic contaminants. The organic material is used as a substrate for microbial growth, resulting in decomposition of the organics. Inorganic contaminants that may be present are not treated and remain in the sludge or effluent. Aerobic processes may decompose simple and complex organic compounds, while anaerobic processes can only decompose simple organics. The effectiveness of biological treatment is determined by a number of factors, these include;

- the type of organic contaminant
- the concentration of the contaminant

- the presence of inhibitors
- the extent of acclimatization of bacterial populations to the waste
- the period of time the waste is in contact with the microbial population (CCME, 1989).

Thermal treatment is used to break down organic hazardous wastes by exposing them to high temperatures. This results in the destruction of the liquid or solid phase components of the waste. Incineration is the most common thermal treatment, altering the chemical, physical or biological composition of the waste thus converting the waste to a less bulky, less toxic or less noxious material (Meakin, 1992 Sinclair, 1986). The most common types of incinerators used are liquid injection incinerators for pumpable liquids, and rotary-kiln incinerators for solids, liquids, sludges and slurries (Santoleri, 1988, Schaefer and Albert, 1988). Some additional thermal treatments include, thermal desorption, thermal oxidation, plasma destruction and pyrolysis processes.

The effectiveness of any treatment process varies with a number of factors (CCME, 1989), these include;

- The concentration of pollutants. In wastes with high concentrations of contaminants, treatments may remove a large percentage of the contaminants, but the effluent will still have a high absolute amount of contaminant. The addition of large amounts of additives that may be required for physical or chemical treatments may be a concern.

- Waste stream composition. Additional contaminants in a waste stream may have a significant effect on the efficiency of a particular treatment.
- Operating characteristics. Waste streams may vary in their concentration and composition, which may require a flexible treatment system. The effectiveness of a treatment system may depend on the treatment systems ability to change operating characteristics to suit the particular waste stream.

In most university settings final treatment is not carried out except in the case of large quantity hazardous wastes. This is largely due to capital costs of equipment and the need to comply with changing regulatory requirements.

2.6 Hazardous Waste Disposal

Treatment of hazardous wastes often result in residues that require final disposal. The disposal of these residues is done to prevent the material from escaping into the surrounding environment. The two types of disposal currently available are, secure landfill and subsurface or underground injection. After the material is treated and stabilized it is placed in the containment area. Disposal techniques used for hazardous waste vary, but almost all universities utilize off-site services from private contractors.

2.7 Summary

The literature review highlights the complexity of the hazardous waste issue. Even the development of a standard definition is no easy task. There are many methods available to research and educational institutions for minimizing the amount of hazardous waste requiring specialized disposal. Not all of these methods are universally applicable. One thing that is clear, however, is that the proper handling of hazardous waste, including documentation, segregation etc., will ensure that the greatest number of management techniques can be applied to the waste stream prior to any final disposal option.

For example, through reduction, the amount of hazardous waste that ultimately requires disposal decreases, resulting in significant cost savings to the generator. Reduction also decreases concerns of legal liability and concerns of potential environmental contamination. In developing a proper hazardous waste management program it is important to consider the roles of reducing, reusing recycling and recovery, sometimes referred to as the four R's. The use of these management techniques can help avoid the possibility of potentially harmful wastes entering the environment. The first step in implementing the alternative management techniques noted in the literature is the consideration of the existing management system.

Chapter 3

Hazardous Waste at the University of Manitoba

3.1 University of Manitoba Hazardous Waste Program

Since consideration of the existing hazardous waste management system is critical to identifying and implementing any new initiatives, the current hazardous waste management program at the University of Manitoba is outlined. The information in this chapter was obtained through a series of personal communications with John Zaidan, the Hazardous Waste Technician with the University of Manitoba Safety Office. The survey questions outlined in Appendix 5, and used to survey other universities (See Chapter 4) were also used as a framework for the discussions with University of Manitoba Safety Office officials.

The University of Manitoba hazardous waste program consists of four components including, a protocol for receiving hazardous wastes, a classification system, a computer tracking system, and management methods, fully discussed later in this chapter. The Environmental Health and Safety Office is the responsible authority for all hazardous waste management at the University. The Safety Office operates a hazardous waste storage facility at the Fort Garry Campus. The facility consists of two storage areas, one an explosion proof module which also has heat detectors with a fire suppression system and spill containment. This module is CSA approved for flammable storage. The other storage area is a modified barn used to store non-volatile wastes. The storage facility has been upgraded to enable packaging of compatible wastes. All hazardous wastes are transported to the facility in a van modified for this purpose.

Hazardous wastes received the University of Manitoba since July 1994 have been entered into the database using the current classification system (Appendix 3). The section of the database from July 1994 to July 1995 has been used to determine waste stream volumes (Table 3.1). During this period a total of 660 kilograms and 3773 litres of hazardous waste were received by the Safety Office, a volume considered to be relatively small.

In addition to the items in the table, items such as asbestos and biohazardous waste (ie. sharps) are received by the Safety Office but are sent to a domestic waste landfill (Brady Road).

As previously mentioned, the main legislation regulating the management of hazardous waste at the University of Manitoba is the provincial Dangerous Goods Handling and Transportation Act, along with a number of its regulations. The transportation regulations also apply to wastes transported from the Bannantyne

Table 3.1: Volumes of respective hazardous waste streams received by the University of Manitoba Safety Office between July, 1994 and July, 1995.

Labpack Categories	**Amount Received**	
	Kilograms	**Litres**
Code A - Inorganic Acids - Elements and inorganic acid salts that do not liberate gaseous products when acidified	58	91
Code B - Inorganic alkaline chemicals - Organic bases - Elements and inorganic alkaline salts	161	121
Code C - solid organic compounds, excluding organic bases	360	137
Code D - organic liquids excluding bases, resins and paints	18	145
Code E - Inorganic oxidizing agents	17	29
Code F - Organic/inorganic pesticides, herbicides, rodenticides	14	30
Code P&R - Paints, resins, thinners - Resins, glues, adhesives and non-reactive activators	- 6	- 47
Code CG Aerosols	-	111
Code S - Special disposal items	14	16

Bulk Waste Categories	**Amount Received**	
Code A - Acids		
1) Inorganic acid solutions	-	-
2) Organic acid solutions	-	-
3) Oxidizing acid solutions	-	-
Code B - Bases		
1) Inorganic alkaline solutions	-	-
2) Organic bases		
	-	-
Code C - Organic solids		
1) Solid organic compounds	-	-
Code D - Organic liquids		
1) Organic non-halogenated liquids, excluding bases, resins and paints	4	871
2) Organic halogenated liquids		
3) Formaldehyde solutions	8	204
4) Ethidium bromide solutions	-	120
5) Acetonitrile solutions	-	43
6) Antifreeze solutions	-	319
	-	-
Code E - Inorganic oxidizing solutions		
1) Inorganic oxidizing solutions		
	-	-
Code F - Pesticides, herbicides, rodenticides		
1) concentrated liquid	-	-
2) diluted rinsate	-	-
3) bulked powders	-	-
Code O - Oils		
1) Oil mixtures	-	1395
2) Oily water	-	40
Code P - Paint		
1) Oil based paints, varnishes	-	54
2) Latex paints	-	0.4
Code R - Resins, isocyanates		
1) Resins, glues, adhesives	-	-
2) Isocyanates	-	-

Campus to storage facilities at the Fort Garry Campus. Hazardous wastes transported around the Fort Garry Campus do not fall under these regulations. Regulations regarding generator registration and spill reporting apply to all hazardous wastes generated at the University. The Manitoba Environment Act provides additional regulations that affect hazardous waste management, including regulations about storage and handing of gasoline and associated products, waste disposal grounds, and control of pesticides.

The University of Manitoba Hazardous Waste Management Advisory Committee (HWMAC) operates to complement the hazardous waste management activities of the Safety Office. The duties of the HWMAC are, to put forth recommendations on policy and procedures for the safe and effective management of hazardous waste at the University of Manitoba and, to ensure compliance with regulations. They provide advice on these matters and submit reports and recommendations to the Workplace Health and Safety Advisory Committee.

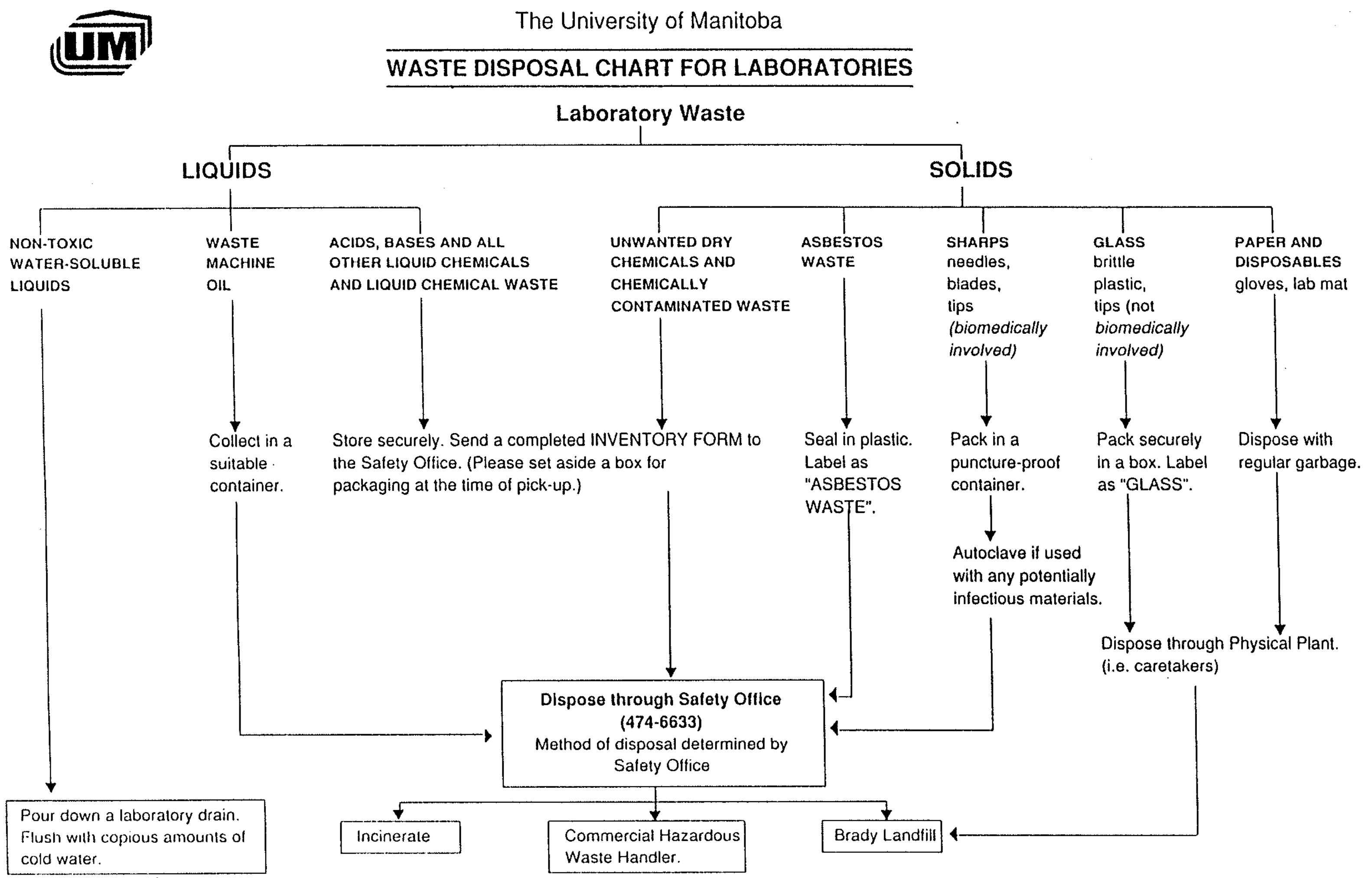
3.1.1 Hazardous Waste Management Protocol

The protocol used by the Safety Office at the University of Manitoba is relatively straight forward. Figure 3.1, for example, shows the waste disposal procedures for laboratories at the University. Generators either call or submit a hazardous waste removal form to the Safety Office to request collection (Figure 3.2). The waste is collected once a week by a Hazardous Waste Technician. The waste is taken to a storage facility where it is either stored, bulked, or lab-packed with other compatible materials until taken away for final disposal by a contractor.

Other than the flow chart shown in Figure 3.1 there is no formal documentation of a hazardous waste management protocol at the University of Manitoba. Generators other than laboratories generally follow a process similar to Figure 3.1. Once hazardous wastes are collected from any generator on campus, disposal is paid for by the Safety Office with no direct charge back to the generators of the wastes.

Interviews with Safety Office staff indicate that they feel that the current protocol for receiving hazardous waste works well for the University because of its simplicity. This simplicity helps to ensure cooperation by waste generators. Since a relatively small amount of hazardous waste is generated at the University of Manitoba there is also some flexibility in the procedures for the pick-up of items. For example, generators may add items at the time of pick-up and incorrect entries on the hazardous waste removal form can be corrected at the time of pick-up.

The University of Manitoba hazardous waste system does not contain steps that allow generators to classify wastes. The Safety Office feels that the greatest compliance will result from a system that places few requirements on the generators. Once collected, all hazardous wastes are classified by the technician at the Safety



NO CHEMICALS ARE TO BE LEFT FOR THE UNIVERSITY OF MANITOBA CUSTODIAL STAFF. Empty reagent bottles are to be rinsed and have the labels de-faced. All potentially infectious materials (*biomedically involved*) must be autoclaved or de-activated using a chemical sterilizing agent prior to disposal. Animal carcasses are to be incinerated. Radioisotope users should consult the University of Manitoba "Waste Disposal Chart For Radioisotope Users".

THE ABOVE CHART IS A GUIDE, MORE INFORMATION IS AVAILABLE THROUGH THE OCCUPATIONAL HEALTH & SAFETY OFFICE (474-6633).

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Figure 3.1 University of Manitoba Waste Disposal Chart for Laboratories

Figure 3.2 University of Manitoba Hazardous Waste Removal Form

HAZARDOUS WASTE REMOVAL FORM

DATE:_______________

USER NAME	
DEPARTMENT	
LOCATION OF WASTE	
PHONE NUMBER	

Please label all containers clearly with the chemical names(s).

Containers with unknown contents will be handled separately. Please call the number listed below if unknowns are present.

Please avoid the use trade names, abbreviations or chemical formulas for chemical names.

Chemical Name(s)	Number of Containers	Container Size

Please return to: John Zaidan, Environmental Health & Safety Office

Room 191 Frank Kennedy Centre, University of Manitoba

Phone: 474-6316; Fax 275-0849

Safety Office Use

P\U DATE:		ENTERED:	

office based on information given by the generator. In this regard, the Chemistry department recently requested information on the rules governing on-site segregation and bulking of their wastes. As a result the Safety Office is preparing guidelines for this activity. They are cautious, however about extending this practice to other departments due to concerns about waste handling by untrained people.

As the above discussion shows, the only hazardous waste management requirement placed on generators at the University of Manitoba is to call the Safety Office when they have something that needs to be picked up. Decisions about waste management are therefore left to the Safety Office - the end of the pipe solution. To say that the Safety Office is an end of the pipe solution is not meant to imply indifference or lack of concern about hazardous waste on the part of generators or the Safety Office. It is a term used in the waste management industry to describe waste management considerations taking place only after the waste is generated. In most cases the Safety Office will not be aware a particular waste is being generated until they get a request for pick-up or advice. This type of system may result in some quantities of hazardous waste being disposed improperly with the Safety Office unaware of it. A hazardous waste audit is a technique that is used to determine hazardous waste generation. Part of an audit involves tracking hazardous material from their purchase through their processes and to disposal.

The Safety Office intends to become more proactive in their efforts to determine the amount of hazardous waste being produced. As well, they are currently developing a waste minimization information package to be distributed to all hazardous waste generators. Unfortunately this package will be very generic while it is likely generators will require case specific advice (Zaidan, pers comm). This package will enable high volume, high cost or high risk waste streams to be targeted.

Generators of hazardous waste at the University do not receive training in hazardous waste identification, minimization etc. They do receive Workplace Hazardous Materials Information System (WHMIS) training through the Safety Office.

3.1.2 Classification of Hazardous Waste

Once picked-up by the Safety Office the hazardous wastes are classified into waste streams based on disposal method and cost of disposal. Waste stream classification occurs according to how the waste will eventually be packaged. The waste streams are divided into three types; lab-packs, bulk drums and specials (Table 3.2 and Appendix 3). Lab-packs are drums containing individual containers of hazardous waste belonging to the same category. Bulk drums contain liquid hazardous wastes that can be combined. There are nine lab-pack categories which are based on disposal industry standards. There are also nine bulk waste categories, some of which are further subdivided. The bulk classification system is of a similar format to the labpack classification system (e.g. Code A are acids, Code B are bases. Table 3.2).

Hazardous wastes at the University of Manitoba are not classified by Transportation of Dangerous Goods (TDG) codes for internal tracking purposes. The lab-packs and bulk wastes are classified by TDG codes only at the time of removal by the outside contractor. This classification is entered on the manifest by the waste disposal company. As a regulatory requirement, TDG codes are used for hazardous wastes transported from the Bannantyne Campus to the storage facility at the Fort Garry Campus.

3.1.3 Tracking of Hazardous Waste

The University of Manitoba uses a computer system for storing data on hazardous waste. The system consists of a database program operating on an IBM type computer. Each container of hazardous waste picked up by the Safety Office is given a unique identification number which is entered into the database. Additional information that is also entered includes, waste name, generator information, and disposal information.

The system has the ability to allow categorization by management methods through the use of additional information fields. Information such as recycle codes may be entered into the database in these additional fields.

At this time the Safety Office is using the database to provide an inventory of the waste items received. A listing of all items to be disposed is provided to the disposal companies to enable them to bid on disposal contracts.

Other options in the database include the capability to generate reports from the information entered. A number of different software packages are available to assist and enhance the reporting capabilities of the database.

3.1.4 Hazardous Waste Minimization Methods

The following activities have been undertaken in an attempt to reduce the quantity of hazardous waste generated at the University of Manitoba.

- substitution of latex paint for oil-based paints used by maintenance staff
- substitution of water based materials in the Art Department
- education of some generators on a case-by-case basis to reduce hazardous waste contaminated debris such as rags and gloves
- introduction of micro-laboratory techniques in the Chemistry Department
- substitution of halogenated solvents in the Chemistry Department

Presently, a chemical redistribution system is also operating out of the Chemistry Department at the University of Manitoba. The 'Free Stores' mainly involves the Chemistry Department but there is increasing involvement of other departments. Chemicals are redistributed free of charge to those requesting them. It has been estimated that over a one year period the equivalent of approximately 200 x 200g bottles of chemicals have been redistributed (Cross, 1995 pers comm). As well, a non-university use for waste toluene was identified with Boeing Canada of Winnipeg who now receive any toluene wastes that become available.

Currently, wastes that are segregated and sent for off-site recycling include batteries and motor oil. Solvent distillation is not being carried out on a large scale on campus, however, the Chemistry Department is redistilling some of their waste solvents. Many solvent wastes are also sent for recycling by the waste disposal company that picks up wastes at the University. Hence the waste classification system identified earlier ensures that wastes are bulked to allow for reuse or recycling after collection. A previous investigation by the Safety Office determined that the volumes of waste solvents did not justify the purchase and operation of a solvent distillation unit on campus (Gusdal, pers comm).

Solvents (along with other organics of high BTU value) that are not recycled, are fuel blended by the currently contracted disposal company for energy recovery. Non-halogenated scintillation fluids and a small amount of solvents are also incinerated in the University of Manitoba power plant. Not all solvents are incinerated since it is sometimes difficult to determine if they are non-halogenated.

3.1.5 Hazardous Waste Treatment

Other than incineration of some non-halogenated solvents, there is no on-site treatment of hazardous waste at the University of Manitoba. Some treatments will be examined following the completion of the new hazardous waste storage facility. Treatments are often, however, much more expensive and labour intensive than disposal through a commercial disposal company.

3.1.6 Other Management Methods

The hazardous waste facility is used for repackaging/bulking of hazardous waste. This does not reduce the quantity of hazardous waste produced, but reduces the cost of disposal.

3.1.7 Hazardous Waste Disposal at the University of Manitoba

Disposal of hazardous waste at the University of Manitoba is contracted to commercial disposal companies. The particular disposal company is selected through a tendered bidding process. The most recent disposal contract was awarded to Laidlaw Environmental Services. Several previous disposal contracts have been handled by the Manitoba Hazardous Waste Management Corporation. Disposal of the various hazardous waste streams often requires that wastes be sent to several different facilities in Canada and the United States. Tables 3.2 shows the disposal methods used by Laidlaw Environmental Services for the waste streams from the University of Manitoba.

Table 3.2. University of Manitoba labpack and bulk waste streams and disposal methods as carried out by Laidlaw Environmental Services (Hinton, pers comm)

Labpack Categories	**Disposal Method (Laidlaw)**
Code A - Inorganic Acids - Elements and inorganic acid salts that do not liberate gaseous products when acidified	bulked, neutralized and sent to secure landfill
Code B - Inorganic alkaline chemicals - Organic bases - Elements and inorganic alkaline salts	bulked, neutralized and sent to secure landfill
Code C - solid organic compounds, excluding organic bases	reacted, neutralized and sent to secure landfill, or if not highly volatile sent to rotary kiln
Code D - organic liquids excluding bases, resins and paints	bulked, fuel blended and incinerated
Code E - Inorganic oxidizing agents	reacted, neutralized and sent to secure landfill
Code F - Organic/inorganic pesticides, herbicides, rodenticides	bulked and sent to cement kiln in U.S. that is licensed for pesticides
Code P&R - Paints, resins, thinners - Resins, glues, adhesives and non-reactive activators	sent to recycling facility or fuel blended and incinerated
Code CG Aerosols	liquid drained and incinerated, cans sent for scrap metal recycling
Code S - Special disposal items	case-by-case basis

Bulk Waste Categories	Disposal Method (Laidlaw)
Code A - Acids 1) Inorganic acid solutions 2) Organic acid solutions 3) Oxidizing acid solutions	neutralized, liquid is incinerated and solids sent to secure landfill
Code B - Bases 1) Inorganic alkaline solutions 2) Organic bases	reacted, neutralized and sent to secure landfill
Code C - Organic solids 1) Solid organic compounds	incinerated in rotary kiln or sent to secure landfill
Code D - Organic liquids 1) Organic non-halogenated liquids, excluding bases, resins and paints 2) Organic halogenated liquids 3) Formaldehyde solutions 4) Ethidium bromide solutions 5) Acetonitrile solutions 6) Antifreeze solutions	incinerated
Code E - Inorganic oxidizing solutions 1) Inorganic oxidizing solutions	reacted, neutralized and sent to secure landfill
Code F - Pesticides, herbicides, rodenticides 1) concentrated liquid 2) diluted rinsate 3) bulked powders	bulked and sent to licensed cement kiln in U.S.
Code O - Oils 1) Oil mixtures 2) Oily water	recycled or incinerated
Code P - Paint 1) Oil based paints, varnishes 2) Latex paints	recycled or fuel blended
Code R - Resins, isocyanates 1) Resins, glues, adhesives 2) Isocyanates	reacted or to rotary kiln or to secure landfill

3.2 Generator Perceptions of Management Program

In addition to the information from Safety Office personnel, the views of waste generators at the University were obtained. This information was collected by telephone from six individuals who had requested pick-up for greater than one hundred hazardous waste containers during a single year. It was hoped that their frequent use of the hazardous waste management program would enable them to provide some insight.

When asked their opinion of the University of Manitoba hazardous waste collection system, all indicated that it worked quite well. The only problem identified was that "unknowns" (waste items whose contents are not known) are not picked up by the Safety Office. One departmental technician reported that he is storing a fairly large amount of unknowns because there is nothing he can do with them. The Safety Office does not identify unknowns because the process of identification of each unknown can represent a significant cost. The Safety Office will assist the generators in identifying unknowns, however, the generators must pay the cost of this.

When generators were asked their opinion on the usefulness and effectiveness of instituting a charge back system rather than continuing with the current system, responses were varied. Those that agreed that a charge back system would be good, usually indicated they had major concerns about the source of funding for such an initiative. One respondent stated, "Morally, as producers of the waste we should be prepared to pay for the disposal, but grant money is limited". Another respondent indicated that he would approve of a charge back system and include the cost of disposal in his grant applications. None of the respondents questioned felt that a charge back would encourage non-compliance.

When generators were asked if they would like to receive more training, and if they were willing to play a larger part in the hazardous waste program, most agreed that this would be a good idea and the responsible thing to do. One departmental technician indicated that he already had too much to do and would just as soon leave it to the Safety Office.

3.3 Summary

Based on the literature review and communications with the Safety Office and generators at the University, a number of strengths and weaknesses about the University of Manitoba hazardous waste program can be seen.

The strengths of the hazardous waste program include the following: the system for receiving hazardous waste has been kept simple to ensure compliance and provide flexibility in the receiving of hazardous wastes; a computerized tracking system has been adopted which can be used for reporting and waste stream analysis; wastes are being lab-packed and bulked on site, reducing the cost of disposal; a chemical redistribution system is being operated which has been successful in diverting a number of items from disposal. Substitutions for hazardous materials have been made in some cases.

A number of weaknesses also exist with the hazardous waste program at the University, including the following: the Safety Office is seen as an end-of-the-pipe solution; the Safety Office lacks complete awareness of all hazardous waste generating activities; there are no identified steps outlined for the involvement of generators in the management of hazardous waste; the Safety Office and the generators are essentially unaware of each other's activities when it comes to hazardous waste management; the generators are, for the most part, uneducated about hazardous waste minimization techniques and have no real incentive, financial or otherwise, to reduce the hazardous waste they generate; there is an inability to deal with unknown hazardous wastes which causes difficulties since neither the department storing the unknowns, nor the Safety Office, can afford to spend the money identifying them; the computer database, along with other software has the capability to generate reports on various aspects of hazardous waste generation, however, this capability is not yet being used; finally, the centralized purchasing system is not being used to provide inventory control or information about hazardous material purchases.

Chapter 4

Hazardous Waste at Other North American Universities

4.1 Introduction

Given both the strengths and weaknesses of the current hazardous waste management system at the University of Manitoba and the need to confirm the success of alternative management techniques outlined in the literature, surveys were carried out with officials from a selection of universities in Canada and the United States. It was hoped that this information would, in particular, identify options that would lead to solutions to the identified weaknesses in the University of Manitoba hazardous waste management program.

The questions used in the interviews were developed with the assistance of the practicum committee members (Appendix 5). Initial participants in the interviews were identified as universities using alternative hazardous waste management techniques. Alternative techniques include any techniques or methods that reduce the amount of hazardous waste generated or the amount requiring disposal by contracted companies. Additional participants were recommended by the initial participants interviewed. In total, twenty respondents completed the interviews.

4.2 Hazardous Waste Management Program

During the interviews it was requested that participants send information regarding their respective hazardous waste management programs, including procedures, protocols and computer tracking systems. Most respondents indicated that there was very little formally written about their program or protocol, much like the University of Manitoba. Additionally, many indicated that the computer programs in use for tracking hazardous waste were written by an individual programmer at the university with little backup documentation available. Seven of the twenty individuals interviewed provided additional information as requested.

All of the respondents to the interview indicated that their institution had a "hazardous waste management program". On further discussion with the participants it became clear that there were different ideas about what a hazardous waste management program involved. It seemed that some felt this just meant collection and disposal. For example, not all of the surveyed universities carried out what could be considered hazardous waste minimization. Other universities considered minimization to be part of management.

Responses to the question on legislation varied by jurisdiction. In Canada, respondents indicated most often that hazardous waste is controlled by provincial legislation and regulations. In addition, they noted that there may be municipal bylaws and regulations in the communities in which the universities are located. An example of this is, the Sewer Use Bylaw for the city of Victoria enacted in August of 1994. This bylaw states what materials may or may not be disposed of in the sewer. In Winnipeg, the Sewer Utility Bylaw (bylaw 5058/88) covers the discharge into the city sewers. Essentially, it says that no dangerous or hazardous materials may be discharged into the sewer.

Respondents from the United States noted that each state controls and regulates hazardous waste to a minimum standard as set out in the federal Resource Conservation and Recovery Act (RCRA). Some states adopt the RCRA as their own standard while other states such as Minnesota, California and Massachusetts have developed stricter regulations.

The respondents were asked about the protocol they use at their respective institution for tracking and control of hazardous waste. The purpose of this question was to find out how the hazardous waste managers were receiving the hazardous waste, what information was required from the generators, the packing and labelling requirements and, how the protocol was being used for hazardous waste minimization.

It was discovered that all of the universities use a management protocol similar in some aspects. All of the receivers require the generators to submit a request form with information about the generator and the waste. The hazardous waste personnel pick up the waste and take it to a central storage area where it awaits disposal. In many cases the similarity in the hazardous waste management protocol ends here, with minor differences existing among the various institutions.

Some institutions request a minimum amount of information from the generator. This includes, generator name, department, phone number, location of the waste, chemical name, number of containers and container size. The Safety Office at the University of Manitoba is one of the institutions that requests this information from the generators (Figure 3.2). Other institutions require more information about the waste and the generation of waste. As well, they provide detailed information about how the forms are to be filled out (see Figure 4.1 and 4.2).

There are a number of reasons for the differences in the amount of information required by the receiving offices. Some of the respondents indicated that they provide annual reports regarding volumes and types of hazardous waste to both the administration and to individual generators. Without exception, the more detailed forms were used by universities that provide additional training to it's generators. An example of this is Stanford University where training in hazardous waste identification, labelling, categorization, minimization and disposal is provided.

Most of the respondents indicated that they do not use a charge back system to recover the cost of disposal from the generators. Many felt that it would be counter productive and might encourage generators to dispose of some hazardous wastes improperly. The University of Wyoming is using a newly developed system where 75% of the cost is charged to the generator or department and 25% is charged to the principle office (i.e. research, support, provost or athletics). They are having organizational problems and a large number of complaints about the system. There also seems to be some non-compliance, but they feel they can work this out. The University of Victoria hazardous waste disposal is funded through a charge back to the Dean of the Faculty where the wastes are generated. The University of Guelph operates a system where the generator is charged with the cost only if the waste is an exceptionally large amount. The information was not clear as to what constitutes an exceptionally large amount.

All respondents indicated that the management protocol used at their institution worked relatively well. Most, however, also identified some minor problems with their system. The two most common problems were: lack of, or incorrect information from the generator and the large amount of unknowns or mystery compounds received. In order to rectify the first problem many of the waste managers will not pick-up containers where there is missing or incorrect information. It is felt that this forces the generators to be more diligent and aware of the wastes they produce, as well as more careful in filling out the forms. Other universities, such as University of Manitoba and Memorial University of Newfoundland, do not find this to be a major problem and try to get all the information at the time of pick-up. None of the respondents could identify a suitable solution to the second problem.

HWM-TRK-01: REQUEST FOR PICKUP OF CHEMICAL WASTE

For chemicals and mixtures with UI#s only.
Chemicals without UI# use Form HWM-TRK-02.
New mixtures use Form HWM-TRK-03.
Original containers less than 100 g/ml use Form HWM-TRK-04.

☐ Form HWM-TRK-02 included
☐ Form HWM-TRK-03 included
☐ Form HWM-TRK-04 included

DEHS Use Only
Date Received: ________
Location ID#: ________
Pickup Request #: ________
Total Containers: ________

Date: ____________ Location of Waste (Room & Building): ____________________ Location ID #: ________

Request submitted by (print): ____________ Phone: ________ Supervisor: ____________ Supervisor phone: ________ (optional)

By my signature, I certify that the information contained on this form is true and correct to the best of my knowledge. ____________________ signature

Campus mail address: ____________ room, building MC-______

UI #	Chemical Name—must match UI# (No formulas or abbreviations)	Number of identical containers	Original Container Size	Amount Remaining	Units (circle one)	Usable? (circle one)	If not excess material, describe process generating waste	Color of Chemical	Phase (liquid, solid, gas, sludge)	Number of layers
					Kg L	Y N				
					Kg L	Y N				
					Kg L	Y N				
					Kg L	Y N				
					Kg L	Y N				
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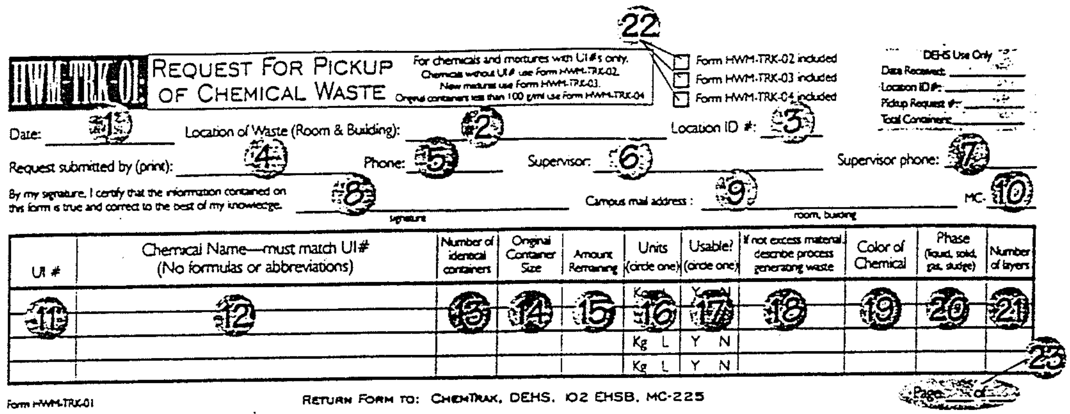
Form HWM-TRK-01 (Rev 12-8-94) **Instructions on reverse side** RETURN FORM TO: CHEMTRAK, DEHS, 102 EHSB, MC-225 Page ____ of ____

Figure 4.1: University of Illinois at Urbana-Champaign Request for Pickup of Chemical Waste (front)

Figure 4.2: University of Illinois at Urbana-Champaign Request for Pickup of Chemical Waste (reverse side)



Step by Step Instructions for completing form HWM-TRK-01

Note: Please enter all information requested. Incomplete forms may delay your waste chemical pickup.

1 Enter the date (Month Day, Year) you are filling out the form. [The dates on each form need not be the same.]

2 Enter the location where the waste can be found. Be sure to give both the room number and the building name or initials.

3 Enter your location ID number. This can be found in your copy of the *UIUC Chemical Waste Management Guide* or from your supervisor. If you can't find your number, you can request it via email to hazwaste@uiuc.edu. As a last resort, you may call 244-0416, and ask for assistance. Please have your lab location(s), contact name(s) and phone number(s) handy.

4 Print your name legibly.

5 Print your phone number.

6 Print your supervisor's name. In the case of labs, this is usually your principal investigator. [This is the same name that should be associated with your location ID number.]

7 OPTIONAL: Print your supervisor's phone number.

8 Sign your name. This should be the same name printed in block 4, above. The purpose of this signature, is to satisfy legal requirements for identification of waste. By signing this block, you are saying the attached information is correct, and saves the University from performing costly analysis on your waste.

9 Print your campus mail address. This is VERY important, as we will return labels for your waste to this address via campus mail.

10 List your campus mail code. [MC stands for mail code.] Ask your departmental secretary if you don't know it. Mail codes are also listed in the UIUC Phone Book.

11 Look up each chemical in the UIUC Master Chemical List in your *UIUC Chemical Waste Management Guide*. Copy the UI# from the guide to this spot.

12 Enter the chemical name. Do not abbreviate. Do not write chemical formulas. This chemical must match the UI# listed in space 12.

13 Write the number of containers of this chemical only. There should remain about the same amount of chemical in each container. If the amount per container is different, use additional lines.

14 Write the size of the original container. Estimate the amount if you don't know. Please use kilograms or liters only. Do not write a unit in this block—you will be circling a unit in space 17.

15 Write the amount remaining in the container. Estimate the amount if you don't know. Use only kilograms or liters. Round amount to the nearest 0.1 kg or liter. This space MUST be completed, or the line will be rejected. You may use the following APPROX conversion factors:

1 gal = 4 liters	1 lb = 0.5 kg	1 quart = 1 liter
1 pint = 0.5 liter	1 ounce (liq or solid) = 0.03 liter or kg	

16 Circle the unit the corresponds to the amount written in space 16. [Note: Kg = kilograms; L = liters]

17 If the chemical has never been opened or is a stable material that has been opened and is still usable, circle Y. Otherwise, circle N.

18 If your chemical is simply no longer needed, leave this space blank. Otherwise, use a word or short phrase to describe the process that generated the waste. e.g., "extraction", "cleaning", "etching".

19 Use one of these colors which best matches your waste: white, black, red, yellow, orange, blue, green, purple, brown, colorless.

20 Use one of the following words which best matches the physical state of your waste: solid, liquid, gas, sludge.

21 How many layers are there in your waste? On this form, "1" will be the most common answer.

22 Check each box, as appropriate, if this submittal has any of the other Hazardous Waste Management ChemTrak forms attached. Each of these forms is described to the left of the check boxes.

23 Just before you send your form(s) in, place them in the following order: First—all of this form; Second—all of form HWM-TRK-02; Third—all of form HWM-TRK-03; Last—all of form HWM-TRK-04. Count the total number of forms and write it in the second blank line on all of the sheets. Then starting with this form, number them consecutively in the first blank.

Note: if all of your chemicals are on the UIUC Master Chemical List (or Generic Mixture List), you need use this form only.

Staple your pages together and send them to:
ChemTrak, DEHS, 102 EHSB, MC-225.

Most of the respondents indicated that they did not require the generator to classify the waste, feeling that they would rather do it themselves to prevent mistakes. In most cases the generators were not trained in classifying hazardous waste. For example, one university reported "...it was a hassle to try and get all the untrained generators to do it, and they often ended up doing it wrong or were constantly phoning the Safety Office".

A few of the universities do have the generators do some classification. The University of Minnesota, Stanford, Washington State and Tufts University require the generators to classify the waste by hazard class and it is then further classified by the receiving department. Memorial University of Newfoundland requires the generator to classify the waste by the TDG codes on the pickup request form. The wastes are further classified as necessary at the Department of University Waste. Universities that require some generator classification provide training to assist them.

All respondents questioned said that there were no provisions in the protocol that provided generators with steps to implement management methods. Most respondents indicated that reduction or minimization of hazardous waste by the generators was encouraged but there was no formal protocol. Four respondents indicated that waste minimization was included in their training program (Only one Canadian university surveyed, the University of Waterloo, had a training program). Information about the various training programs was requested, but was not received.

Another four universities indicated that they provided the generators with guidebooks and information or newsletters (see examples, appendix 4) on hazardous waste minimization, but it was not considered part of their management protocol. The respondents that encouraged waste reduction or provided education or training indicated it was mainly in source reduction of hazardous waste. This included methods such as changes in laboratory practices, substitution, or changes in purchasing. They were cautionary about enabling generators to treat the wastes themselves.

The universities in the United States indicated that EPA permits were required for any management activities beyond simple neutralization, and that permits were difficult to get. The remaining respondents indicated that there were no steps, formal or informal in place for management methods to be implemented by generators. Some of the respondents indicated that there was no initiative for generators to implement any sort of management methods since there was no charge back system in place, - "The generators do not have a financial interest in reducing the amount of waste". One respondent explained that they have no real control over what goes on until they get the request for disposal from the generator.

Given the above, it is not surprising that all respondents answered "no" when asked if their protocol allowed for any waste management decisions to be made by the generator. It was felt that this was the domain of the receiving office. At two of the universities, some decision making was carried out by hazardous waste management committees, however their role was more advisory in nature. At Stanford University a training program is conducted for generators and their opinions and suggestions are encouraged, but they did not have decision making power.

All of the Canadian universities surveyed use the TDG classification system as a minimum. The TDG system is required by regulation in all provinces for shipping hazardous waste. In Ontario, the Ministry of the Environment also requires the use of MOE codes (same as UCD codes) for identification and tracking (Appendix 2). The Universities of Guelph, Waterloo, Victoria and Saskatchewan classify by additional codes supplied by industry disposal companies. These codes enable staff to lab-pack or bulk wastes as required by disposal companies. This results in significant cost savings on disposal. The University of Victoria has contracts with three different disposal companies and classifies waste streams by disposal company requirements and waste type.

Universities in the United States face different regulatory requirements. Generators classify hazardous waste by EPA codes from their listed wastes as well as DOT codes for shipping purposes. As in Canada some of the universities surveyed indicated that they utilize additional codes for disposal and/or treatment purposes. For example, Stanford University includes codes for twenty major volume waste streams. The basis of this is that they are repetitive wastes. Generators that provide grater than five gallons a week of one of these wastes, such as formaldehyde, are not required to submit a request for pick-up form for each container. They submit a single 'blanket' form indicating that they will be providing a quantity of a certain waste on a regular basis. Washington State University has a number of waste streams for on-site treatment, bulking, and lab-pack considerations.

The respondents were also asked about their tracking systems. Six of the respondents indicated that they tracked wastes manually and did not use a computer system. All six were Canadian universities. Two of these respondents indicated that they felt a computer system would be extra work and redundant since all the information was on the shipping manifests. In addition, university administration and/or government did not require reports of information about volumes and waste types generated. Two of these respondents noted, however, that a computer system was being developed for the future.

The remaining fourteen universities used a computer system in their hazardous waste management program. Seven of these fourteen identified each waste item by a unique identification number. Typically, this number corresponded to the form number on the 'request for pick-up' form, otherwise it was simply a numerically increasing number. Three of the respondents entered waste items by generator name. Four of the respondents entered waste items by chemical name or Chemical Abstract Services (CAS) number or TDG number. The system automatically added additional information about the chemical. The remaining respondent identified the waste item by the drum where the waste was located. The systems where the waste items were entered by a method other than unique number automatically assigned a identification number to the item. A few of the systems used the unique number in a bar code system. Bar codes were a useful method of tracking wastes from pick-up to disposal. In general, the method of data entry appears to be a function of the programming of the database rather than a function of management implications.

The computer systems were used in management to varying degrees among the universities surveyed. Some of the computer systems were used as simple inventory systems and to print out lists for disposal companies. Other universities such as Colorado State used their systems to generate barrel content records, manifest sheets, and container tags. At Colorado state, when a request for pick-up is received, the information is entered into the system and a corresponding container tag is generated. This tag is sent to the generator and attached to the container. Based on the information received, the operator determines what barrel the waste is to go in. The information is transferred to the barrel container records, which is automatically updated. These barrel container lists are used to generate manifest lists for the disposal companies.

Many universities use their systems to provide reports about generators and their individual waste production. These reports may include information about types of wastes and volumes generated as well as the cost of disposing the waste. Many hoped that this information could be used to help identify where individuals could reduce waste production.

Four respondents indicated that their computer system allowed categorization by management method to some extent. In all of these systems the programs contained extra fields which allowed entry of information on management methods such as, reuse, recycling or treatment for a particular waste. When the same waste type was received again that information would automatically show up on the screen, indicating to the operator what was to be done with that item. One example is UBC, where additional classifications are; treated on-site, disposed on-site, neutralized on-site, recovery on-site and disposal off-site. The system at the University of Minnesota will automatically flag items with the potential to be redistributed. These items are then placed in another storage area and added to a list distributed to all of the campuses. Some systems do not allow for redistributed items because only items that are to be disposed of are entered into the system.

There were few responses to the question about other options incorporated into the tracking systems. Several respondents indicated that their systems were developed very recently and they were 'just getting used to it'. The computer system at the University of Victoria allows reports to be produced itemizing wastes by generator, which are then passed on to the generator or faculty. Many respondents indicated that their system could generate reports, however, it was not clear if they were doing so. The system at UBC facilitates invoicing of non-university generators who are charged for disposal. The University of Saskatchewan computer system informs the user of high volume waste streams; for example, formalin from the Veterinary College and Hospital.

Many respondents indicated that their computer system was new and the users had not yet realized the potential of what they could do, or would like to do, with it. There were two common responses in regards to what the users would like to see incorporated in the computer tracking system. The first involved the incorporation of an inventory for hazardous materials. This would allow hazardous waste managers to track these materials from purchase to disposal and enable them to get a better idea of waste reduction possibilities. A bar code system was another option that managers would like to see incorporated into their systems. At this time three of the universities are using bar code systems to track their hazardous wastes. Additional desirable options mentioned were, better reporting capabilities, and a system where all pertinent forms (eg, barrel list, manifest form) could be automatically updated when a new waste was entered into the system.

The remaining part of the interview dealt with the identification of alternative methods and techniques used by universities to minimize the amount of hazardous waste requiring disposal. For the purpose of presentation, responses are presented in the sections suggested by the respondents, including reduction, reuse, recycling, recovery, treatment and disposal. In many cases the methods were not implemented by the personnel responsible for hazardous waste management, but by the departments or faculty producing the waste. The management methods are presented in a summary form and in no particular order.

The following is a list of what has worked in reducing or eliminating the production of particular types of hazardous wastes at the institutions surveyed.

- substitution of soy bean based inks in printing
- substitution of less hazardous cleaning solutions in janitorial, housekeeping and mechanical shops
- substitution of water based paints and solvents
- substitution of non-mercury thermometers
- reducing the amount of chemicals bought in bulk
- training modules for generators, including newsletters about waste minimization and lab practices
- substitution of formaldehyde, formalin, toluene, and xylene
- working with purchasing department to develop an inventory system to identify hazardous materials entering campus
- setting up a purchase control system to eliminate excess inventory of hazardous materials
- annual room inspections

- on-line laboratory inventories with campus wide access
- substitution for biological controls for pesticide use
- substitution of water based scintillation cocktails
- substitution for chromic acid cleaning solutions
- eliminate production of hazardous waste in entry level chemistry classes
- micro-scale analytical equipment in chemistry
- computer simulations and modelling in laboratories to replace experiments
- sending staff to state pollution prevention training program
- providing departments with reports on their hazardous waste generation and costs of disposal
- segregating hazardous and non-hazardous waste
- segregating hazardous waste streams (eg. halogenated, non-halogenated solvents) (reduces disposal costs)

When questioned about the reuse of hazardous wastes, the following responses were given.

- campus wide redistribution program for chemicals
- redistribution program in Chemistry department
- some redistribution with other U of Minnesota campuses in state
- exchange of some chemicals with local high schools
- use of xylene from histology department for equipment cleaning
- direct reuse of acetone in anatomy department

- some solvent reuse for parts cleaning
- reuse of various grades of methanol

When questioned about recycling of hazardous wastes, the following responses were given.

- solvent distillation; either sell back to generator or return at no charge
- distillation of acetone, ethyl alcohol, isopropyl alcohol to better than reagent purity; provide spectral analysis to user
- use of Safety Clean parts washing system. Closed system with solvent being recycled after use
- off-site recycling of motor oil and anti-freeze
- waste organic solvents sent to cement kiln for fuel
- off-site recycling of scrap metal from solvent drums

There were few responses about the types of wastes from which resources were being recovered.

- silver recovery from photochemicals, done on-site and off-site by contractor
- off-site recovery of mercury by contractor

In spite of the relatively small volumes of the hazardous waste streams generated at the institutions, the following techniques are being used to treat some of the waste streams.

- using bleach to destroy cyanide
- dilution of photochemicals after silver recovery
- neutralization of acids and bases
- ethidium bromide treatment with bleach
- dilution of aqueous solutions for discharge into sewer
- blending of solvents with radioactive organic waste for dilution and disposal (This treatment is legal, but generally not an accepted practice)
- dewatering of some wastes to reduce volume
- gluteraldehyde and formaldehyde treatment for discharge into sewer
- deactivation using redox reactions

Finally, most respondents gave no response when asked about any other waste management methods or techniques identified for reduction of hazardous wastes. The following responses were given.

- biological treatment of contaminated soils from leaky tanks (likely a one time occurrence)
- burning of liquid scintillation cocktails in boiler
- four respondents indicated that trying to gain some sort of purchase control would be desirable and that it could have a significant impact on waste management

4.3 Summary

The survey of other research and educational institutions provided information about the level of their hazardous waste management and minimization efforts.

The following is a summary of what methods and procedures were useful and efficient in university hazardous waste management programs.

1) Generators are required to submit a 'request for pick-up' to the appropriate office with information describing the waste and the generator of the waste.
2) Generators are provided with training in hazardous waste identification, labelling, categorization, minimization and disposal. Training eliminates or greatly reduces the problem of a lack of generator information and the receiving of unknown wastes.
3) This training is supplemented with updated bulletins or guides on methods or practices for waste reduction. The main focus of waste minimization education is in source reduction, such as improved laboratory practices.
4) Input and suggestions from generators on how management practices and waste reduction methods may be improved are regularly invited. Implementation of waste reduction methods by generators are encouraged, with consultation of hazardous waste managers.
5) Annual reports on waste volumes, types, and disposal costs are provided to individual generators and departments. This gives the generators an idea of their contribution to hazardous waste production and provides waste managers

information on where efforts may be focused.

6) Classification of hazardous waste to allow for internal management involving classification for disposal options (eg: lab-packing or bulking of compatible materials), with additional identification of material with alternative management options.

7) Use of a computer based tracking system allowing more flexibility in monitoring and reporting of waste.

8) Entering wastes into the database by unique identification number allowing for tracking of individual items. Unique identification number can also allow the system to store information such as class codes.

9) Computer systems allow items that have been identified as having alternative management options such as, redistribution, treatment, etc. to be flagged when entered. In addition, the computer system may flag items of high importance. These could be items on which managers may want to focus reduction efforts, such as the most hazardous wastes.

10) The use of computer tracking systems allows the implementation of bar code systems for easing waste tracking. Information may be easily transferred from container to drum contents list and to manifest list. Computer system can also be used to generated all lists, forms, and generator waste reports.

The following is a summary of the types of management efforts found to be useful in minimizing the amount of hazardous waste requiring disposal by commercial methods.

1) Development of a centralized purchasing system linked to inventory monitoring for hazardous materials.

2) Training and education of generators in all relevant departments on waste minimization techniques, including housekeeping, inventory control, substitution, laboratory practices, segregation, etc.

3) Providing reports on waste activity and disposal costs to generators.

4) Implementation of a campus-wide redistribution program for unused chemicals. Provision of an accessible on-line inventory of items available for redistribution.

5) Solvent distillation with a return to generator or to other lower grade user.

6) Off-site recycling of materials such as motor-oil, batteries, and scrap metal.

7) Silver recovery from photochemicals.

8) Simple treatments of some materials as last step in reaction or general on-site treatment of larger amounts.

The information obtained during the interviews underscores that the hazardous waste management programs at many other universities have followed the same basic path as the University of Manitoba and consequently have similar strengths and weaknesses. In spite of this, a number of interesting and innovative management techniques have been identified that warrant further consideration in the University of Manitoba context.

Chapter 5

Improving Hazardous Waste Management at the University of Manitoba

5.1 Introduction

This chapter involves a discussion of changes that could be made to improve the University of Manitoba hazardous waste program. Identified changes are based on what was found to work at other institutions and also on responses received by generators and Safety Office staff at the University of Manitoba.

5.2 Improvements to the Hazardous Waste Management Program

The Safety Office is seen as an "end-of-the-pipe" solution to the hazardous waste generated on campus. They often have little or no information about types and amounts of hazardous materials purchased and the activities that generate the hazardous waste. This makes it difficult to identify alternatives for the source reduction of hazardous waste.

One option available that would assist in correcting the lack of information problem, and likely increase the management options available to the Safety Office is the modification of the University purchasing system. The University of Manitoba currently uses a centralized purchasing system and all purchase requests go through the purchasing department. Consultation of the Safety Office by the purchasing department is not required prior to the purchase of hazardous materials. The only exception to this is radioactive substances, since they must pass through the Safety Office. Therefore, the Safety Office does not have an inventory of the type or quantity of hazardous materials purchased at the University limiting their ability to identify a host of viable management options.

Concern over the lack of an inventory of hazardous materials is not new. A 1993 study identified several University of Manitoba purchasing practices that had implications regarding hazardous waste generation, including:

- Freedom of user departments and researchers to specify products, including quantity. This enables chemicals to be purchased in more economical, bulk quantities without consultation of similar users that may share the same item.
- Purchasing to ensure lowest price, without taking into account other costs, such as disposal.
- Small central inventories that promote the use of overly packaged goods at small volumes. (Ladd, 1993).

These practices can result in: overpurchasing of materials which may become outdated and thus require disposal; prevention of identification of non-hazardous substitutes, and; prevention of sharing of hazardous materials among users.

The current purchasing system could be modified to prevent this by including some form of inventory control. Inventory control involves implementing a system where all hazardous material purchases would be accounted for by an identified office or individual. Once all hazardous material purchases are identified the responsible authority could then identify opportunities for shared use of materials, potential substitutions, and purchase of materials based on use and not unit-cost.

The idea of having a centralized purchasing system with inventory control was generally met with scepticism by the University of Manitoba generators contacted. One person felt that there would be considerable difficulties and that it would not be practical (Thachuk, pers comm). Another indicated that for research purposes he would strongly oppose it, however for teaching purposes it would be a good idea (Pinsky, pers comm). There were also concerns of bureaucratic failure and the organization of such a system (Robinson, pers comm).

Despite the concerns of generators at the University of Manitoba others see this approach as essential to effective hazardous waste management. For example, Colorado State University is currently implementing a buying and contracting system so they can have control and knowledge of what materials enter the University. Linking an inventory control program of this sort to the purchasing system provides information on high volume users and, reduction opportunities. Essentially, this would be a cradle to grave system for tracking hazardous material.

Education of generators would provide another improvement to the hazardous waste program. Presently, training in hazardous waste identification, minimization, classification, labelling etc. is not given on campus. Advice and information is given to generators as requested. To allow generators to do their part to minimize the wastes they produce, they need to be educated about all aspects of hazardous waste management. The University could conduct training seminars for all generators. These could be easily tied in to the existing WHMIS training program. In addition to this training, guidebooks and bulletins could be developed or adapted from other sources. The University of Illinois at Urbana-Champaign provides a series of chemical waste and waste minimization bulletins (See Appendix 4 for examples). Adoption of this type of educational program by the University, with or without training seminars, would help reduce laboratory hazardous waste.

Part of the training and education of generators at other universities includes identification and encouragement of improved laboratory practices to reduce hazardous waste. There are several improvements that could be implemented. These include: micro-scale experiments, elimination of hazardous waste in entry-level classes and, treating waste products as the last step in the experiment. The bulletin in appendix 4 lists additional ideas.

Generators questioned felt that if they had more information on waste reduction they and other generators would be more likely to act than those with no information. Also, some felt that if generators had this type of training, opinions and suggestions for better management would likely arise. It is likely in this regard that the users of the hazardous materials know more about the materials and their potential uses than staff at the Safety Office.

Of the generators asked, most felt that some sort of workshops would be a good idea. There was a mixed response to the notion of generators taking any extra responsibility for hazardous waste. One person felt that he would prefer to leave everything to the Safety Office (Thachuk, pers comm).

A charge-back system, where the generators are charged for disposal of the wastes they produce has been identified as another important management technique. A charge-back system involves charging the generator a fee based on the amount of waste they produce or charging them the cost for disposal of the waste they produce. During the interviews of University of Manitoba generators opinions on this were mixed, with some saying it would work, and others saying it would encourage non-compliance. The universities surveyed that had such a system believe it is, and will continue to be an effective way to encourage generators to take part in hazardous waste minimization.

As an initial step the Safety Office could use reports that identify individual waste generators and their waste production quantities on a regular basis. This would at least make generators aware of the true cost of handling and disposing of their hazardous waste. Since information about generators is already entered into the Safety Office database, reports on disposal costs could be easily generated even if charge-back is not instituted.

In addition to reporting on handling and disposing charges, several other applications could be added to the computer tracking system aimed at further improving hazardous waste management at the University of Manitoba. For example, the computer system could be used to flag previously identified wastes that have alternative management options, such as at the Universities of Minnesota and Saskatchewan. This has been very effective in identifying wastes that can be redistributed. The computer system could be updated to allow generation of all forms and container lists along with automatic updating. This type of system could be modified for use with a bar code system.

5.3 Options for Minimizing Hazardous Wastes at the University of Manitoba

Changes in the management system described in section 5.2 could enable or assist in the establishment of several techniques designed to reduce the quantity of hazardous waste generated at the University. In addition to those changes, a number of other changes could be implemented to minimize waste.

Through the examination of the database and also the literature review and interviews some substitutions have been identified that could be examined further for their application to University of Manitoba wastes. Table 5.1 indicates wastes, including amounts, received by the Safety Office from September 1993 to July 1994 that might be substituted. The mixtures listed might continue to be a hazardous waste after substitution, depending on the other contents. Each case needs to be examined carefully.

As indicated, a chemical redistribution system operates at the University of Manitoba. This system could be expanded to include other departments, particularly those in science, agriculture and engineering. Also, the 'Free Stores' inventory could be placed on the campus 'gopher' computer system for access by other departments and users. The extension of this redistribution to other institutions, such as the University of Winnipeg or local high schools is also a possibility.

Reusable materials could be placed on the Manitoba Waste Exchange Network. Since the last federal budget there have been changes to this Network and its future is not certain. However, the probable form of the Exchange, if it continues to exist, will be a passive system consisting of a national database (Lohvinenko, pers comm). It is likely that materials suitable for this exchange system are the same ones redistributed through the Free Stores. Materials not suitable are those containing other

Table 5.1: Wastes received between September 1993 and July 1994 with possible substitutes. Total amounts received along with number of items received also listed.

Waste type (no. received)	**Volume Received**	**Potential substitute**
Benzene (15)	18.25 L	Alcohol
Benzoyl peroxide (3)	325 gr	Lauryl peroxide
Chloroform (33)	77.45 L	1,1,1-trichloroethane
Chloroform containing wastes (4)	5.1 L + 1 cont.	
Carbon tetrachloride (7)	7 L	Cyclohexane 1,1,1-trichloroethane 1,1,2- trichlorotrifluoroethane
Formaldehyde (19)	22.6 L	Peracetic acid Formaltermate Ethanol
Formaldehyde containing wastes (9)	3 L + 473 gr	
Formalin (22)	14.8 L	see formaldehyde
Formalin containing wastes (7)	24.4 L	
Sodium dichromate (4)	3.9 Kg	Sodium hypochlorite
Toluene (21)	39.7 L + 5 gr + 1 cont	Simple alcohols and ketones
Toluene containing wastes (11)	32.1 L + 505 gr	
Xylene (31)	38.8 L + 480 gr	Simple alcohols and ketones
Chromic acid (4)	11 L	various
Mercury thermometers (8)	8	alcohol thermometers

contaminants. The exchange operates through a system of postings of "wastes wanted" and "wastes available".

Wastes that can be recycled locally, such as batteries and motor oil, are presently being handled in such a way. Solvent distillation is not being carried out on a large scale on campus since volumes of recyclable waste solvent are not high enough to justify it. The Chemistry Department is redistilling some of their waste solvents. There might be potential to redirect additional waste solvents to the Chemistry Department. Campus wide solvent distillation could be re-examined in the future to determine its economic feasibility as changes in volumes of waste occur. Solvents that can be recycled could be segregated from non-recyclable solvents to enable recycling by the disposal company.

Some hazardous wastes generated at the University of Manitoba have been identified as having potential for on-site treatment, such as ethidium bromide. The use of treatment processes will depend on the volume of the waste available, the cost of treatment, and any public safety issues. Additionally, many wastes will require a series of treatments to be fully neutralized. For example, many acids or bases contain other contaminants which, after neutralization, would still make them hazardous. Table 5.2 contains a listing of wastes received by the Safety Office that may have the potential for on-site treatment. These are wastes identified through the interviews as easily treatable, thus not requiring handling and treatment through a private

Table 5.2: Wastes received that have potential for reduction through treatment along with volumes and number of items received.

Waste Type (no. received)	**Volume Received**
Ethidium bromide (18)	85 L + 8.2 gr
Ethidium bromide containing wastes (58)	127 L + 23 Kg + 13 containers + 5 bags
Gluteraldehyde (4)	0.175 ml
Formaldehyde (19)	22.6 L
Formaldehyde containing wastes (9)	3 L + 473 gr

contractor. Also, many chemical wastes may be treated as a final step in an experiment.

5.4 Summary

A number of alternatives are available that could be adopted to improve the hazardous waste management program at the University of Manitoba. These alternatives considered here included: changes to the purchasing system; generator education, a charge-back system; the substitution of some hazardous materials with non-hazardous materials; and the selected treatment of some hazardous wastes.

Chapter 6

Summary, Conclusions and Recommendations

6.1 Summary

This study documented the current hazardous waste management program at the University of Manitoba. It also identified alternative methods of hazardous waste management that could reduce the volume of hazardous waste generated by the University of Manitoba, and identified the role generators may have in the hazardous waste management decision-making process.

The study methods consisted of: a review of related literature to identify possible alternatives; interviews with hazardous waste managers at twenty Canadian and American universities to identify the state of hazardous waste management across North America; analysis of the University of Manitoba hazardous waste database to identify volumes of waste streams and wastes that are potentially substitutable and treatable.

6.2 Conclusions

The first objective was to categorize hazardous waste streams at the University of Manitoba. As described in chapter 4 hazardous waste streams are currently categorized as shown in appendix 3. When this practicum topic was first identified and subsequently undertaken there was no hazardous waste stream classification system in place. Several changes were implemented with the hiring of John Zaidan in the fall of 1994 as a full-time hazardous waste manager. The University of Manitoba hazardous waste facility was also upgraded to enable bulking and lab-packing of hazardous wastes. On-site lab-packing and bulking does not reduce the amount of waste being generated, however it does result in a reduction in the cost of disposal for the University. This upgrading required that a system of classification be adopted so compatible materials could be placed in their respective lab-pack drums or bulk drums.

Additional options for classification were considered. Classification based on level of environmental hazard was one option considered. Waste streams identified as being the most hazardous would then be the focus of minimization efforts. The present classification system does not allow for this because each hazardous waste stream can consist of items that range significantly in level of hazard (Zaidan, pers comm). Classification by legislative requirements is used by a number of the universities interviewed, however this system is not useful for identifying and implementing management options. This form of classification was not considered for the University of Manitoba since it would not be conducive to hazardous waste minimization.

The second objective was to identify and develop options for reducing, reusing, recycling and disposing of the products in these waste streams. A number of different techniques are available to minimize hazardous waste at universities and many are being used by the various universities surveyed. Chapter 5 describes which can be implemented at the University of Manitoba. Many universities find that the small volumes of most waste streams do not justify the cost of treatment. The universities that are recycling or treating wastes, generally find that distillation of solvents and simple neutralization are the most useful and cost effective options. Source reduction through methods such as, purchase control and inventory control, improved laboratory practices and improved practices in other departments, are considered to be easiest and most cost effective.

The third objective was to recommend methods to be used to manage at least the high quantity hazardous waste streams. There are no high quantity waste streams at the University of Manitoba. At many universities solvent wastes are received in high volumes. A previous study by the Safety Office determined that this was not the case for the University of Manitoba. As previously mentioned it may be that some solvent wastes are being disposed of improperly. Although there are no high quantity hazardous waste streams at the University of Manitoba several methods have been identified to reduce hazardous waste production of small volume wastes. As with other universities these methods are mostly source reduction through purchasing procedures and improved laboratory practices.

The final objective was to develop a protocol for hazardous waste management decision making for all current and potential waste streams. As mentioned earlier, most of the universities, including the University of Manitoba, prefer that waste management decisions are made through those in charge of handling the hazardous waste. It is felt that most generators are untrained in the various aspects of hazardous waste management and problems could result. The universities that allow decision making by the generators provide them with training in hazardous waste minimization, identification, etc. At Colorado State University it is felt that generator knowledge is important in the operation of the program. Generators receive training and are required to be certified. At universities where training is provided generators classify the waste and minimization by generators is encouraged.

6.3 Recommendations

This study has identified a number of ways the University of Manitoba can improve the present hazardous waste management program. The University can choose to either follow the present system with the Safety Office as an end of the pipe manager, or the University can move toward requiring more generators to be stewards of the waste they generate. Maintaining the status-quo will, however, limit the management options available for hazardous waste at the University. Through this current system the Safety Office remains unaware of all waste generation activities and generators remain unaware of waste management activities that may result in the reduction, reuse or recycling of the waste they generate. A number of recommendations following from this study have been identified to improve this situation, including the following:

1. The Safety Office should develop waste minimization bulletins to distribute to all generators of hazardous waste (Appendix 4 provides examples). As well, a guidebook outlining the proper requirements for handling, labelling, packaging, reporting, etc. of hazardous waste should be written.
2. Mandatory seminars should be conducted by the Safety Office to educate generators in hazardous waste minimization, labelling, classification, etc. and to discuss alternative hazardous waste management techniques.
3. The Safety Office should conduct a hazardous waste audit, with assistance of other departments, to determine if all hazardous wastes are being received by the Safety Office. Through the audit a complete analysis of management alternatives could also be undertaken. A hazardous waste audit includes tracking hazardous materials from purchase to disposal, including an examination of the processes which generate the wastes.
4. In order to provide an additional incentive to generators to become involved in the reduction of hazardous waste, the Safety Office should immediately begin to notify generators of the cost of handling their hazardous waste. This should be followed with a feasibility study of implementing a charge-back system that would see generators charged a fee based on disposal costs of the wastes they create.

5. The Safety Office should be provided with the resources necessary to stay up to date on state of the art reduction, reuse, recycling, recovery, treatment and disposal options. Safety Office staff should therefore be allowed to attend workshops and seminars. As well, the Safety Office should elicit assistance from the Hazardous Waste Advisory Committee, Faculty and on-line departments. These activities will be necessary in order to adequately develop and maintain bulletins, guidebooks and appropriate seminars as outlined in recommendation 1 and 2.

The above recommendations need to be implemented in order to get generators and the Safety Office working together to more properly manage and minimize hazardous waste production - moving away from end of pipe management. Implementation of the following recommendations would result in further reductions in the hazardous waste stream:

6. The Safety Office should identify ways of modifying the existing centralized purchasing system so that information on hazardous material purchases can be highlighted. This will enable the identification of potential substitutions, opportunities for shared use of materials, and allow the tracking of hazardous materials from purchase through treatment to ultimate disposal if necessary.

7. The Safety Office should expand it's use of their database for, reporting on individual generator waste production, "flagging" of items that have been found to have alternative management methods, and for updating all relevant lists and forms.

8. The Safety Office should identify and promote substitutions for less hazardous materials through the regular bulletins suggested in recommendation 1.
9. The Safety Office, along with additional departments with an interest in the Chemistry Free Stores, should encourage the University to provide funding for the expansion of the Chemistry Free Stores redistribution system. This should at a minimum include an on-line inventory, accessible to the entire University.
10. The Safety Office should examine the potential for the listing of materials on the Manitoba Waste Exchange.
11. The Safety Office should re-examine the potential for on-site distillation of solvents as volumes of waste solvents change.

As noted previously, the University is a small quantity generator of hazardous wastes. The cost of commercial disposal of this waste has decreased since the Safety Office began their own on-site packaging of compatible wastes. Due to this, the cost effectiveness of implementing some of these recommendations may be questionable. However, by implementing these recommendations for hazardous waste management the University would be setting an example for others by accepting stewardship of its wastes. In addition to this, the University should develop an overall pollution prevention strategy that includes hazardous waste management, solid waste management, energy conservation, water conservation, management of ozone depleting substances, etc. Along with the obvious environmental benefits of this, there would also be educational benefits to the students attending the University.

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Appendix 1:
Transportation of Dangerous Goods Classification

Class 1 – Explosives. Products or substances

(a) that are capable, by self-sustaining chemical reaction, of producing gas at such temperature, pressure and speed as to damage the surroundings, or

(b) that are manufactured for the purpose of producing a practical explosive or pyrotechnic effect.

Class 2 – Gases. Not fully specified products or substances that

(a) have a critical temperature less than 50°C or an absolute vapour pressure greater than 294 kPa at 50°C,

(b) exert an absolute pressure in the cylinder, packaging, tube or tank in which it is contained, greater than 275 ± 1 kPa at 21.1°C or 717 ± 2 kPa at 54.4°C,

(c) are flammable liquids that have an absolute vapour pressure of more than 275 kPa at 37.8°C as determined by ASTM test D323 as referred to in Part III of Schedule VI,

(d) are gases in the refrigerated liquid form that have a boiling point less than −84°C at 101.325 kPa absolute pressure, or

(e) are liquid carbon dioxide.

Divisions – Class 2 (Gases). Gases included in Class 2 shall be included in

(a) Division 1, if the gases

(i) are ignitable at normal atmospheric pressure when in a mixture of 13 per cent or less by volume with air, or

(ii) have a flammability range of at least 12;

(b) Division 3, if the gases have an LC_{50} value less than 5 000 mL/m^3 at normal atmospheric pressure by reason of toxicity;

(c Division 4, if the gases have an LC_{50} value less than 5 000 mL/m^3 at normal atmospheric pressure by reason of corrosion effects on the tissues of the respiratory tract; or

(d) Division 2, if the gases are not included in Division 1, 3 or 4.

Class 3 – Flammable liquids. (1) not fully specified products or substances that are liquids, a mixture of liquids or liquids containing solids in solution or suspension and that have a flash point not greater than 61°C are flammable liquids.

(2) the flash point shall be determined by the closed cup test method.

Divisions – Class 3 (Flammable liquids). Flammable liquids included in Class 3 shall be included in

(a) Division 1, if they have a flash point less than −18°C;

(b) Division 2, if they have a flash point not less than −18°C but less than 23°C; or

(c) Division 3

(i) if they are subject to special provision 63, or

(ii) if they have a flash point not less than 23°C but less than 37.8°C and they are to be transported in a domestic consignment or a trans-border consignment. (SOR/85-609, s. 28)

Class 4 — Flammable solids; substances liable to spontaneous combustion; substances that on contact with water emit flammable gases. Not fully specified products or substances that consist of

(a) solids that under normal conditions of transport are flammable for the reasons that

(i) they are readily ignitable and that would burn vigourously or persistently, or

(ii) they cause fire or contribute to fire through friction or from heat retained from manufacturing or processing,

(b) substances that are liable to spontaneous combustion under normal conditions of transport or are liable to heat in contact with air to the point where they ignite, or

(c) substances that on contact with water emit dangerous quantities of flammable gases or become spontaneously combustible on contact with water or water vapour.

Divisions — Class 4 (Flammable solids; substances liable to spontaneous combustion; substances that on contact with water emit flammable gases). Products or substances included in Class 4 shall be included in

(a) Division 1, if they are flammable solids;

(b) Division 2, if they are substances liable to spontaneous combustion; or

(c) Division 3, if they are substances that on contact with water emit flammable gases.

Class 5 — Oxidizing substances and organic peroxides. Not fully specified products or substances that

(a) cause or contribute to the combustion of other material by yielding oxygen or other oxidizing substances, whether or not the product or substance is itself combustible, or

(b) are organic compounds that contain the bivalent "-0-0-" structure.

Divisions — Class 5 (Oxidizing substances and organic peroxides). Products or substances included in Class 5 shall be included in

(a) Division 1, if they are oxidizing substances; or

(b) Division 2, if they are organic compounds that contain the bivalent "-0-0-" structure.

Class 6 — Poisonous (toxic) and infectious substances. Not fully specified products or substances that

(a) in the case of solids with oral toxicity, have an LD_{50} not greater than 200 mg/kg.

(b) in the case of liquids with oral toxicity, have an LD_{50} not greater than 500 mg/kg,

(c) in the case of substances with dermal toxicity, have an LD_{50} not great than 10 000 mg/kg,

(d) in the case of dusts or mists with inhalation toxicity, have an LC_{50} not greater than 10 000 mg/m^3 at normal atmospheric pressure,

(e) have a saturated vapour concentration greater than 0.2 times the LC_{50} expressed in mL/m^3 at normal atmospheric pressure and an inhalation toxicity value not greater than 5 000 mL/m^3 at normal atmospheric pressure, or (SOR/85-609, s. 30)

(f) are organisms that are infectious or that are reasonably believed to be infectious to humans or to animals and the toxins of such organisms,

shall be included in Class 6 referred to in the schedule to the Act.

Divisions — Class 6 (Poisonous (toxic) and Infectious substances). Products or substances included in Class 6 shall be included in

(a) Division 1, if they are included in Class 6 paragraphs (a) to (e); or

(b) Division 2, if they are included in Class 6 paragraph (f).

Class 7 — Radioactive materials. Products, substances or articles containing a product or substance with activity greater than 74 kBq/kg are radioactive materials and included in Class 7 referred to in the schedule to the Act.

Class 8 — Corrosives. Not fully specified products or substances that

(a) have been known to cause visible necrosis of human skin tissue,

(b) cause visible necrosis of the skin tissue of an albino rabbit at the contact site within a period of four hours or less when administered by continuous contact with the intact bare skin of the rabbit,

(c) corrode SAE 1020 steel or 7075-T6 non-clad aluminum surfaces at a rate exceeding 6.25 mm per year at a test temperature of 55°C using the metal corrosion test method set out in Part VI of Schedule VI, or

(d) are wastes that have a pH factor less than 2.0 or greater than 12.5.

Class 9 — Miscellaneous products or substances. (1) Miscellaneous products or substances included in Class 9 referred to in the schedule to the Act shall be the products or substances assigned to Class 9 in List II of Schedule II.

(2) Miscellaneous products or substances referred to in subsection (1) are included in

(a) Division 1, if they are miscellaneous dangerous goods;

(b) Division 2, if they are hazardous to the environment; or

(c) Division 3, if they are dangerous wastes.

Appendix 2:
University of California at Davis (UCD) Classification

Description of UCD Waste Categories

Inorganics

(11) *Acidic solutions* (usually contain HCl, H_2SO_4 or HNO_3):
(111) ... with heavy metals (antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, indium, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, vanadium and/or zinc)
(112) ... with other metals and non-metals (typically contains an alkali metal, e.g. Na, K)
(113) other acidic solutions (acidic solutions not containing metals or non-metals, or acidic solutions with no component information provided)

(12) *Alkaline solutions* (usually contain NaOH, KOH, or NH_4OH):
(121) ... with heavy metals (see (111) above)
(122) ... with other metals and non-metals (see (112) above)
(123) other alkaline solutions (alkaline solutions not containing metals or non-metals, or alkaline solutions with no component information provided)

(13) *Metal-finishing solutions* (from process identification on manifest, e.g., "metal plating," "pickling bath," etc.):
(131) ... acidic (per component listing)
(132) ... alkaline (per component listing)
(133) spent pickle liquor (process identification)

(14) *Other aqueous (salt) solutions* (frequently acidic or basic solutions which are neutralized by generator, yielding a salt solution):
(141) ... with heavy metals (see (112) above)
(142) ... with other metals (see (113) above)
(143) solution containing reactive anions (includes cyanide, sulfide, fluoride, hypochlorite or bromate)
(144) other aqueous solutions (aqueous solutions (14) other than (141), (142), (143) or (145))
(145) brine (category 15, California manifest)

(15) *Inorganic solids:*
(151) inorganic solids (activated carbon, cement, etc.)
(152) inorganic chemicals (miscellaneous salts, etc.)

(16) *Other inorganic wastes:*
(161) asbestos-containing wastes (per component information)
(162) aluminum or tin wastes (per component information)
(165) spent catalyst (usually silica-alumina or zeolite, containing trace metals and carbonaceous deposits)
(167) unidentified inorganic wastes

Organics

(21) *Spent solvents* (per Part 261.31 of Federal Register): Halogenated solvents containing chlorine (e.g. trichloroethylene), bromine, or fluorine:
(211) ... with heavy metals (see (111) above)
(212) ... with other metals (see (112) above)
(213) other halogenated solvents, incl. mixed (trichloroethylene, chloroform, carbon

tetrachloride. etc.
Non-halogenated solvents may include oxygenates (e.g., acetone, methylethylketone, etc.)
(214) ... with heavy metals (see (111) above)
(215) ... with other metals or non-metals (see (112) above)
(216) other non-halogenated solvents, including mixed (solvents identified, and containing no metals)
(217) unspecified solvents (category 5, Cal. manifest, with no component information)

(22) *Other organic liquids* (liquids not included in EPA "solvent" listing):
(221) ... with halogens and metals
(222) ... with halogens (chlorine, bromine, fluorine) only
(223) ... with heavy metal only
(224) other organic liquids (not in (221), (222), or (223))
Organic residues frequently include such contaminants as chloroform, acetone, trichloroethylene, etc. These solutions commonly result from cleaning and degreasing operations.
(225) aqueous solution with organic residues <10% (from composition information)
(227) ... with organic residues >10% (composition)

(23) *Organic solids* (as identified in composition):
(231) ... with halogens (see (222))
(232) ... without halogens

(24) *Other organic wastes:*
(241) pesticides and wastes (pesticide production, waste and rinse water containing pesticides, and pesticide containers not clearly specified as empty)
(242) polychlorinated biphenyls (PCBs) and material containing PCBs (transformer fluids, contaminated materials, e.g. soil)
(243) pharmaceuticals and wastes (from Cal. manifest process identification)
(244) photochemicals and wastes (virtually all from photoprocessing laboratories)
(245) off-specification or aged organics (miscellaneous)
(248) still bottoms (distillation residues) without halogens

(251) tannery wastes (many components, including aqueous chromate solutions, and organic materials such as fat and hide)
(253) detergent and soap (liquid, aqueous waste solutions, and organic solids from production or cleaning operations)
(254) adhesives or glue (per composition)
(255) unspecified organic wastes (organics not listed in above categories)

(26) *Polymeric material and wastes:*
(261) polymeric resin (phenolic, epoxy, polyester, urethane, etc., per component data)
(262) latex and wastes (per composition)
(263) other polymeric wastes (off-spec. materials, crushed cases, discarded material from polymer reactors)

(27) *Biological wastes:*
(271) sewage sludge
(272) other biological wastes (incl. animal fat, molasses wastes, and dough)

(28) *Oily wastes* (multiple components):
(281) waste oil and mixed oil (per consumption)
(282-289) oil-containing wastes which are mixed with tank bottoms (282), mud/sediment and water (283), acidic (284) or alkaline (285), solids, oil/water-separation sludge (286), sludge (287), (unspecified, not in (282)-(286) or (288)-(289)), with heavy metal contaminants (288), (See (111) above), with water (289)

Sludges (other than those identified above)

(41) *Relatively inert sludges:*
(412) filter cake (contaminated filter material, e.g., diatomaceous earth)
(413) gas scrubber sludge (from gas cleaning operations)
(416) ink sludge
(417) alum and gypsum (mineral) sludges

(43) *Metal sludge:*
(431) heavy-metal sludge (see (111) above)
(433) other metal sludges (e.g., contains salts of iron, aluminum and/or alkali metals)

(44) *Other sludges:*
(441) lime sludge (from neutralization processes; may contain heavy metals)
(442) phosphate sludge
(443) sulfur sludge (includes sludge with high content of non-heavy metal sulfides)
(445) plating or metal finishing sludge (from identifiable process, metal content unspecified)
(446) degreasing sludge (from cleaning of metal parts; contains solvents)
(447) tetraethyl lead sludge
(453) paper sludge/pulp (paper and cardboard manufacture source)
(454) paint sludge (many possible components, including heavy metal (chromium) and organic solvents)
(456) other waste treatment sludge (sludges not otherwise identified due to lack of composition data)
(457) sludges with organic residues (includes some halogenated components)

Miscellaneous

(509) Gas cylinders or containers
(510) flue-gas scrubber liquid
(511) rinse water and wastewater (contains small units of oil, solvent, metals and/or mud; also bilge water)
(512) spill clean-up (includes miscellaneous organics, liquid fuels)
(513) laboratory waste chemicals (diverse)
(514) contaminated soil and sand (Cal. manifest category 11)
(515) drilling mud (Cal. manifest category 10)
(518) dust-collector wastes
(519) fly ash and retort ash (combustion-generated particulates: mineral matter plus some carbon)
(521) spent cartridge filters (gas/liquid cleaning)
(523) tank bottom sediments (Cal. manifest category 9; composition typically ill-defined)
(524) chemical toilet wastes (Cal. manifest category 7)
(525) metal dust and machining wastes, primarily ferrous and aluminum based alloys
(526) cannery wastes (Cal. manifest category 12)
(527) mud/sediment and water
(531) contaminated rags/pellets
(532) contaminated equipment, containers
(535) totally unspecified wastes

Appendix 3:
University of Manitoba Hazardous Waste Classification Codes

Labpack Categories

Code A

- Inorganic acids (i.e. hydrochloric acid or sulfuric acid)
- Elements and Inorganic acidic salts that do not liberate gaseous products when acidified (i.e. solids of pH range 7 - 1, sulfate salts, boric Acid)

Code B

- Inorganic alkaline chemicals (i.e. sodium hydroxide)
- Organic bases (i.e. amines, pyridines)
- Elements and inorganic alkaline salts (i.e. copper oxide, sodium sulfide)

Code C

- Solid organic compounds, excluding organic bases (i.e. sodium acetate, phenol, carboxylic acids)

Code D

- Organic liquids, excluding bases, resins and paints (i.e. alcohols, ketones, aldehydes, esters, organo-acids, halocarbons)

Code E

- Inorganic oxidizing agents (i.e. permanganates, nitrates, perchloric acid)

Code F

- Organic/Inorganic pesticides, herbicides, rodenticides

Code P&R

- Paints, varnishes and thinners
- Resins, glues, adhesives and non-reactive activators (i.e. isocyanates, polymers)

Code CG

- Aerosols

Code S

- Special disposal item (i.e. Cyanides, air and water reactives)

Bulk Waste Categories

Code A - Acids

1) Inorganic acid solutions (i.e. hydrochloric acid or sulfuric acid)
2) Organic acid solutions (i.e. acetic acid)
3) Oxidizing acid solutions (i.e. nitric acid)

Code B - Bases

1) Inorganic alkaline solutions (i.e. sodium hydroxide)
2) Organic bases

Code C - Organic Solids

1) Solid organic compounds, (i.e. ethidium bromide gels)

Code D - Organic Liquids

1) Organic non-halogenated liquids, excluding bases, resins and paints (i.e. alcohols, ketones, aromatics, esters, organic scintillation fluids)
2) Organic halogenated liquids (i.e. methylene chloride, 1,1,1-trichloroethane)
3) Formaldehyde solutions
4) Ethidium Bromide solutions
5) Acetonitrile solutions
6) Antifreeze solutions

Code E - Inorganic Oxidizing Solutions

1) Inorganic oxidizing solutions (i.e. permanganates, nitrates, periodic acids, perchloric acid, chromium trioxide solutions)

Code F - Pesticides

1) Pesticides, herbicides, rodenticides concentrated liquid
2) Pesticides, herbicides, rodenticides diluted rinsate
3) Pesticides, herbicides, rodenticides bulked powders

Code O - Oils

1) Oil mixtures (used motor, hydraulic, <5% water)
2) Oily water (>95% water)

Bulk Waste Categories (cont'd)

Code P - Paint

1) Oil based paints and varnishes
2) Latex paint

Code R - Resins and Isocyanates

1) Resins, glues and adhesives
2) Isocyanates

Bulk Waste Descriptions

Item/Code	Description of Contents
Formaldehyde/D3	Contains Formalin, Methanol and water
Non-Halogenated Solvents/D1	Contains various solvents, <10% water, no sludge
Halogenated Solvents/D2	Contains various solvents, water, misc. organics
Ethidium Bromide Solutions/D4	Contains debris, some solids, water
Acetonitrile Solutions/D5	Contains organic chemicals, <10% water, no sludge
Inorganic Alkali Solutions/B1	Contains Sodium Hydroxide mainly, water, no sludge
Inorganic Acid Solutions/A1	Contains various acids, water, no sludge
Organic Acid Solutions/A2	Contains various acids, water, no sludge
Antifreeze/D6	Contains Antifreeze, water, no sludge
Pesticides, Concentrate/F1	Contains mainly Herbicides, no sludge
Pesticides, Rinsate/F2	Contains mainly water, <5% Pesticides
Oily Water/O2	Contains >95% water, <2" sludge
Oil Base Paint/P1	Contains <5" sludge
Latex Paint/P2	Contains <5" sludge
Nickel-Cadmium Batteries/	Mainly 8 kg units, some smaller batteries

Additional Notes

All waste will be packaged and labelled in accordance with industry standards and applicable regulations. The drums will all be transportable. Vermiculite will be used as packaging/absorbent material in the labpacks. Inventories of the labpacks will be made available for approval before the waste is packed. Copies of inventories will accompany all labpacks to the destruction facility.

Appendix 4:
Examples of University of Illinois at Urbana-Champaign Waste Minimization Bulletins

Waste Minimization Bulletins

Waste Minimization Bulletin — No. 1

101 Ways to Reduce Hazardous Waste in the Lab

1. Write a waste management/reduction policy.
2. Include waste reduction as part of student/employee training.
3. Use manuals such as the American Chemical Society (ACS) "Less is Better" or "ACS Waste Management for Lab Personnel" as part of your training.
4. Create an incentive program for waste reduction.
5. Centralize purchasing of chemicals through one person in the lab.
6. Inventory chemicals at least once a year.
7. Indicate in the inventory where chemicals are located.
8. Update inventory when chemicals are purchased or used up.
9. Purchase chemicals in smallest quantities needed.
10. If trying out a new procedure, try to obtain the chemicals needed from another lab or purchase a small amount initially. After you know you will be using more of this chemical, purchase in larger quantities (unless you can use some someone else doesn't need any more).
11. Date chemical containers when received so that older ones will be used first.
12. Audit your lab for waste generated (quantity, type, source, and frequency). Audit forms are available from DEH&S.
13. Keep MSDS's for chemicals used on file.
14. Keep information about disposal procedures for chemical waste in your lab on file.
15. If possible, establish an area for central storage of chemicals.
16. Store chemicals in storage area except when in use.
17. Establish an area for storing chemical waste.
18. Minimize the amount of waste kept in storage. Request a chemical pickup as often as you need.
19. Label all chemical containers as to their content.
20. Develop procedures to prevent and/or contain chemical spills - purchase spill clean-up kits, contain areas where spills are likely.
21. Keep halogenated solvents separate from non-halogenated solvents.
22. Keep recyclable waste/excess chemicals separate from non-recyclables.
23. Keep organic wastes separate from metal-containing or inorganic wastes.
24. Keep non-hazardous chemical wastes separate from hazardous waste.

University of Illinois at Urbana-Champaign-Division of Environmental Health and Safety
UIUC DEHS
Chemical Waste Management Section
102 EHSB, 101 S. Gregory St., (MC-225)
email: hazwaste@uiuc.edu phone: 4-0416

25. Keep highly toxic wastes (cyanides, etc) separated from above.
26. Avoid experiments that produce wastes that contain both radioactive and hazardous chemical waste.
27. Keep chemical wastes separate from normal trash (paper, wood, etc.).
28. Use the least hazardous cleaning method for glassware. Use detergents such as Alconox, Micro, RBS35 on dirty equipment before using KOH/ethanol bath, acid bath or No Chromix.
29. Eliminate the use of chromic acid altogether.
30. Eliminate the use of uranium and thorium compounds (naturally radioactive).
31. Substitute red liquid (spirit-filled), digital, or thermocouple thermometers for mercury thermometers where possible.
32. Use a bimetal or stainless steel thermometer instead of mercury thermometer in heating and cooling units. Stainless steel lab thermometers may be an alternative to mercury in labs, as well.
33. Evaluate laboratory procedures to see if less hazardous or non-hazardous reagents could be used.
34. Review the use of highly toxic, reactive, carcinogenic or mutagenic materials to determine if safer alternatives are feasible.
35. Avoid the use of reagents containing: barium, arsenic, cadmium, chromium, lead, mercury, selenium, and silver.
36. Consider the quantity and type of waste produced when purchasing new equipment.
37. Purchase equipment that enables the use of procedures that produce less waste.
38. Review your procedures regularly (e.g. annually) to see if quantities of chemicals and/or chemical waste could be reduced.
39. Look into the possibility of including detoxification and/or waste neutralization steps in laboratory experiments.
40. When preparing a new protocol, consider the kinds and amounts of waste products and see how they can be reduced or eliminated.
41. When researching a new or alternative procedure, include consideration of the amount of waste produced as a factor.
42. Examine your waste/excess chemicals to determine if there are other uses if your lab, neighboring labs, departments or areas (garage, paint shop) who might be able to use them.
43. Review the list of chemicals to be recycled or contact the chemical recycling coordinator (4-7213) to see if chemicals needed are available before purchasing chemicals.
44. Inform the chemical recycling coordinator of the types of materials you can use from the recyclables.
45. Call the chemical recycling coordinator to discuss setting up a locker or shelf for excess chemical exchange in a lab, stockroom or hallway in your department.
46. When solvent is used for cleaning purposes, use spent solvent for initial cleaning and fresh solvent for final cleaning.
47. Try using detergent and hot water for cleaning of parts instead of solvents.
48. Consider using ozone treatment for cleaning of parts.
49. Consider purchasing a vapor degreaser, vacuum bake or bead blaster for cleaning of parts.
50. Reuse acid mixtures for electropolishing.

51. When cleaning substrates or other materials by dipping, process multiple items in one day.
52. Use smallest container possible for dipping or for holding photographic chemicals.
53. Use best geometry of substrate carriers to conserve chemicals.
54. Store and reuse developer in photo labs.
55. Precipitate silver out of photographic solutions for reclamation.
56. Neutralize corrosive wastes that don't contain metals at the lab bench.
57. Deactivate highly reactive chemicals in the hood.
58. Evaluate the possibility of redistillation of waste solvents in your lab.
59. Evaluate other wastes for reclamation in labs.
60. Scale down experiments producing hazardous waste wherever possible.
61. In teaching labs, consider the use of microscale experiments.
62. In teaching labs, use demonstrations or video presentations as a substitute for some student experiments that generate chemical wastes.
63. Use pre-weighed or pre-measured reagent packets for introductory teaching labs where waste is high.
64. Include waste management as part of the pre- and post-laboratory written student experience.
65. Encourage orderly and tidy behavior in lab.

Use the following substitutions where possible:

	Original Material	*Substitute*	*Comments*
66.	Acetamide	Stearic acid	In phase change and freezing point depression
67.	Benzene	Alcohol	
68.	Benzoyl peroxide	Lauryl peroxide	When used as a polymer catalyst
69.	Chloroform	1,1,1-trichloroethane	
70.	Carbon tetrachloride	Cyclohexane	In test for halide ions
71.	Carbon tetrachloride	1,1,1-trichloroethane 1,1,2-trichlorotrifluoroethane	
72.	Formaldehyde	Peracetic acid	In cleaning of kidney dialysis machines
73.	Formaldehyde	"Formalternate" (Flinn Scientific)	For storage of biological specimens
74.	Formaldehyde	Ethanol	For storage of biological specimens
75.	Formalin	See Formaldehyde	
76.	Halogenated Solvents	Non-halogenated Solvents	In parts washers or other solvent processes
77.	Amitrole (Kepro Circuit Systems)	Mercuric chloride reagent	Circuit board etching
78.	Sodium dichromate	Sodium hypochlorite	
79.	Sulfide ion	Hydroxide ion	In analysis of heavy metals
80.	Toluene	Simple alcohols and ketones	
81.	Wood's metal	Onion's Fusible alloy	
82.	Xylene	Simple alcohols and ketones	
83.	Xylene or toluene based liquid scintillation cocktails	Non-hazardous proprietary liquid scintillations cocktails	In radioactive tracer studies
84.	Mercury-free catalysts (e.g. $CuSO_4$, TiO_2, K_2SO_4)	Mercury salts	Kjeldahl digests

85. Polymerize epoxy waste to a safe solid.

86. Consider using solid phase extractions for organics.

87. Put your hexane through the rotavap for reuse.

88. Destroy ethidium bromide using household bleach—see Waste Minimization Bulletin—No. 7.

89. Run mini SDS-PAGE 2d gels instead of full-size slabs.

90. Treat sulfur and phosphorus wastes with bleach before disposal.

91. Treat organolithium waste with water or ethanol.

92. Seek alternatives to phenol extractions (e.g. small scale plasmid prep using no phenol may be found in Biotechnica, Vol. 9, No. 6, pp. 676-678).

93. Use procedures to recover metallic mercury.

94. Review procedures to recover mercury from mercury containing solutions.

95. Recover silver from silver chloride residue waste.

96. Purchase compressed gas cylinders, including lecture bottles, only from manufacturers who will accept the empty cylinders back.

97. When testing experimental products for private companies, limit donations to the amount needed for research.

98. Return excess pesticides to the distributor.

99. Be wary of donations from outside the University. Accept chemicals only if you will use them within 12 months.

100. Replace and dispose of items containing polychlorinated biphenyls (PCBs).

101. Send us other suggestions for waste reduction by campus mail or e-mail to hazwaste@uiuc.edu.

Waste Minimization Bulletins

Waste Minimization Bulletin — No. 2

Conserving Resources for the University

ChemCycle

Conserving Resources for the Environment

UIUC's Chemical Redistribution Program

This bulletin answers a few of the common questions people have about chemical redistribution.

1. What are preowned, excess chemicals?

These are abandoned, obsolete, or otherwise unwanted containers of chemicals generated by overpurchasing, relocation, or change of research emphasis.

Some slightly contaminated solvent streams might also be considered preowned and usable "as is". Chemicals deemed suitable for continued use are designated for redistribution by CWMS (Chemical Waste Management Section) personnel.

These chemicals are available free of charge, including delivery.

2. What are preowned chemicals good for?

Preowned chemicals should be good for most uses of chemicals that you presently have in your lab or studio. Some of these chemicals are "as good as new", coming to us sealed in their original packaging.

In addition, consider which of your processes are qualitative. If they do not require high purity chemicals, it may be worthwhile to obtain them through *ChemCycle*. The table, on the reverse side, shows some examples of uses for preowned chemicals.

If you are starting up a lab or studio or embarking in a new experimental direction, *ChemCycle* can help stock your lab with chemicals to save those valuable research dollars for other purposes!

3. How do I know what is available?

CWMS periodically distributes a listing of excess chemicals. To get on our mailing list, call us, or request this list via email by sending a message to "hazwaste@uiuc.edu".

You can also access the listing electronically. Access the campus Gopher system and find the Division of Environmental Health and Safety gopher hole. Contact your local computer network administrator or the Computing and Communications Services Office (3-6236) if you require assistance.

UIUC DEHS
University of Illinois at Urbana-Champaign Division of Environmental Health and Safety

Chemical Waste Management Section
102 EHSB, 101 S. Gregory St., (MC-225)
email: hazwaste@uiuc.edu phone: 4-0416

4. How do I order from *ChemCycle*?

After signing up and receiving the list, or reading it electronically, complete a request form or email your request to "hazwaste@uiuc.edu". Requests are filled on a first come, first serve basis. CWMS will deliver available items in one to two weeks at no charge. However, if necessary, we can rush an order.

In House Redistribution

Do you have a cabinet full of old chemicals? Could your facility make use of a chemical redistribution program within your building(s)?

If you have a secure, yet accessible location for chemical redistribution within your building, we may be able to help with managing such a site. Call 4-7213 for details.

Examples of Excess Chemicals	Uses of Excess Chemicals
Xylene waste	Cleaning street paint equipment
Sodium Phosphorus pentoxide	Drying agents
Ethylene glycol Isopropanol Silicone oil	Various temperature baths
General acids Sodium hydroxide Potassium hydroxide Ethanol	Cleaning baths
Formic acid Acetic acid Phosporic acid	Decalcifiers
Hydrochloric acid Sulfuric acid	Etching
Cupric sulfate	Lactic acid assay, patinas (art)
Nitrates	Fertilizer, glassblowing oxidants
Non-(or expired) reagent grade solvents	Same use as bulk grade solvents
Potassium dichromate Silver nitrate Various biochemical dyes	Stains
Sodium sulfite Unopened Kodak photochemistry products	Photochemistry
Unopened and opened organic and inorganic solid chemicals	In organic and inorganic teaching labs as well as research experiments

Rev: March 1995

Waste minimization bulletins available from Chemical Waste Management:

No. 1 - 101 Ways to Reduce Hazardous Waste in the Lab
No. 2 - *ChemCycle* - UIUC's Chemical Redistribution Program
No. 3 - Alternatives to Chromic Acid Cleaning Solutions
No. 4 - Alternatives to Mercury and Mercury Compounds
No. 5 - Alternatives to DNA Preps with Chloroform Extractions
No. 6 - Reducing or Eliminating the Use of Heavy Metals
No. 7 - Treatment of Ethidium Bromide
No. 8 - Pollution Prevention in Laboratories: The How to Guide
No. 9 - Waste Reduction Techniques for Paint Application
No. 10-Neutralization of strong acids and bases
No. 11-Used Battery Reduction, Recycling and Management
Call 217/244-7213 or email: hazwaste@uiuc.edu for more information

Appendix 5:
Survey Questions and Participants

Telephone Survey:
re: Kelly Rusk practicum topic
Hazardous Waste Management Alternatives @ U of Manitoba.

Institution name:

Contact Person:
Telephone Number:

1. Hazardous Waste Management Program:
   a) Does your company/institution utilize a hazardous waste management program? Y N

   If so, could I obtain any documentation about your management program, or other information about it?

   b) What is the main legislation that applies to hazardous waste in your jurisdiction?

2. Hazardous Waste Protocol:
   a) What sort of protocol is used by your institution/company for hazardous waste tracking and control?
   Protocol includes how the handling of hazardous waste is organized and any defined procedures carried out by the generators and receivers in handling, documenting and receiving the hazardous waste.

   b) Does this protocol work well with individual generators/dispersed units on campus/in your company? (ie. Do you receive the wastes and information in the manner that you want to receive it?)
   Y N
   Could you provide additional comments on how or why it does/does not work well?

c) Does your protocol include steps for generators to classify the hazardous wastes they produce?
Y N
What are these steps?

d) Does your protocol include any steps for management methods to be implemented by waste generators?
Y N
What are these steps?

e) Does your protocol allow for any waste management decisions to be made by the generators/dispersed units that produce the waste? Y N
If so, in what way?

g) Could I receive a copy of your protocol?

3. Classification:
a) In your management program, are hazardous wastes classified or categorized into hazardous waste streams?
Y N

If so, what classification system do you use? (TDG, UCD, other)

b) What is the basis of choosing this type of classification system? (legislation, management (reduction of waste), tracking, treatment, disposal, cost, environmental impact, etc)

c) Are classified wastes tracked manually or on a computer system?

If tracked on a computer system, how are they entered? (codes, id numbers etc)

d) Does your computer system allow categorization by management methods? (reuse, recycle, etc) Y N
If so, could you explain how this is used?

e) What other options do you incorporate in your tracking system?

f) Do you have any other ideas about what could be incorporated in a automated (computer) system?

g) Could I obtain a copy of, or information about your tracking system?

4 Management Program:
(What types of alternative management techniques are used by the institution/company on the various waste streams in order to reduce hazardous wastes)

a) Waste elimination (housekeeping, purchase control etc):
What has worked well in eliminating the generation of particular types of hazardous wastes?

b) Waste reduction (segregation, concentration):
What has worked well in reducing the amount of hazardous wastes generated?

c) Waste reuse (direct, lower grade use, waste exchange):
What has worked well in regard to reusing hazardous wastes?

d) Waste recycling:
What has worked well for the recycling of hazardous wastes?

e) Resource recovery:
What has worked well in recovering resources and from what type of waste streams?

f) Waste treatment (to non or less hazardous):
What types of techniques have worked well in treating hazardous waste streams?

g) In addition to these, are there any other waste management methods or techniques that you have identified at your institution/company that work well in the reduction of hazardous wastes?

Survey Participants

Randy Alexander, Mark Aston
University of British Columbia

Laurie Boyle
University of Victoria

Kevin Kane
Memorial University of Newfoundland

Sonia Ringer
University of Wyoming

Susan Riggs, Rick Siami
Colorado State University

Carl Schumaker
University of Alberta

Larry Riopka
University of Saskatchewan

Craig Barney
Stanford University

Peter Ashbrook
University of Illinois

Keith Kidd
Tufts University

Rick Grundsten
York University

Jennifer Reader
University of Guelph

Ian Fraser
University of Waterloo

John Jones
Carlton University

Peter Reinhart
University of Wisconsin

Bruce Backus
University of Minnesota

John Reed
Washington State University

Jerry Mason
Brigham Young University

Tony Hammoude
University of Western Ontario

William Louch
Dalhousie University