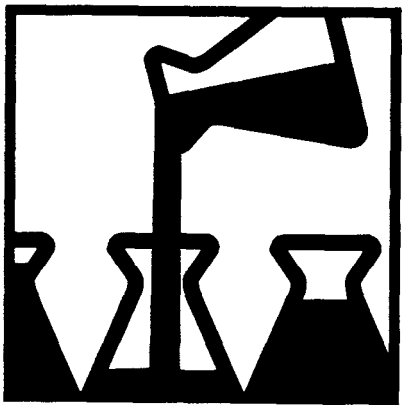
WASTE MINIMIZATION



MANUAL

Analytical Laboratories

Action on Waste
Alberta Environmental Protection.
5th Flr., Oxbridge Place
9820 - 106 St.
Edmonton, AB T5K 2J6

Action on WASTE

Alberta
ENVIRONMENTAL PROTECTION

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Section 1 INTRODUCTION

About This Booklet

This booklet was developed by Alberta Environmental Protection (AEP), Action on Waste, to help analytical laboratories identify and implement waste minimization practices. Practical, how-to information and specific examples of opportunities for minimizing waste are provided. The booklet is aimed at encouraging analytical labs to minimize their waste, which will help the province achieve its goal of reducing waste by 50 percent by the year 2000.

In addition to providing specific opportunities to minimize your waste, it provides a step-by-step process to develop your own waste minimization plan.

Analytical labs in Alberta employ approximately 11,000 people. This includes employees in a variety of types of labs, including private and government, commercial and industrial, and research and educational labs. A relatively large quantity of waste is generated by these labs; estimates are as high as 8700 tonnes per year. This includes both hazardous and non-hazardous waste as well as solid and liquid waste. Efforts by analytical labs to minimize waste can help reduce the quantity and the hazard potential of this waste.

The Waste Challenge

Waste management and disposal is a growing concern among Albertans. Industry, government and the public are becoming more aware of the environmental and economic issues related to waste management and disposal. Some environmental issues of concern are the transportation of hazardous wastes, potential toxic emissions and releases from hazardous waste facilities, the difficulty in siting new landfills and the potential leaching of toxic substances from landfills.

Hazardous waste management and disposal for analytical labs can be quite costly. For example, the cost to dispose of one drum of hazardous waste may be as high as $500, depending upon the contents and the ultimate waste disposal destination. On top of this are transportation costs and costs associated with proper on-site management of hazardous wastes.

While landfill tipping fees are low compared to hazardous waste disposal, the fees in Alberta have increased dramatically over the past few years. This trend is expected to continue as landfill space diminishes and environmental regulations become more strict. In addition, some landfills are imposing bans or surcharges on the disposal of certain waste materials such as cardboard, asbestos and other materials that require special handling or are recyclable.

All of these environmental and economic factors are reasons to consider minimizing waste in your analytical lab. Not only can you contribute towards the waste solutions, but you can benefit as well.

Benefiting From Waste Minimization

The implementation of waste minimization in your business can help the environment and save you money. For example, when you use materials and products more effectively, you conserve resources and reduce waste and pollution. You also save money on materials, products and disposal costs. The extent to which you can save money depends on waste minimization opportunities available to you and your waste hauling and disposal fees. In addition, a waste minimization program that reduces the amount of hazardous waste being handled and disposed of may result in less environmental liability. It can also strengthen existing health and safety programs in your lab by exposing personnel to smaller amounts of hazardous waste.

The Alberta Government is committed to achieving a 50 percent reduction in waste by the year 2000 and is encouraging voluntary waste minimization by Alberta businesses. This will result in less waste entering the environment, and will reduce the regulatory burden of hazardous waste management for both government and business.

Waste minimization should be viewed as part of total quality management and should not compromise the need to meet health and safety standards or good lab practice. It should become part of your management and operations system, and focus on short- and long-term opportunities to reduce waste and save money. As environmental awareness increases and environmental requirements become more strict, waste minimization will become synonymous with good business sense.

The 4Rs of Waste Minimization

Waste minimization in your lab requires the application of the 4Rs: Reduce, Reuse, Recycle and Recover. These are presented in the order of preference based on their environmental benefit and potential for cost savings.

Reduce

This waste minimization measure involves the reduction of waste at the source (sometimes called source reduction). Reduction is the most favourable waste minimization option from an environmental perspective because the consumption of materials and products is reduced and the amount of waste generated is minimized. For analytical labs, reduction also refers to reducing the hazardous nature of waste before disposal. This might include using less hazardous reagents, such as substituting toluene for benzene, or treating reaction

products and spent reagents to make them less hazardous, such as neutralizing strong acids or bases before disposal. Reduction measures are usually easy to implement and provide cost savings in both the purchase of materials and waste disposal.

Reuse

This waste minimization measure involves the direct reuse of a waste material in its original or slightly altered form, which helps extend the life of that material. The reuse option also saves on the cost of buying new materials and products and reduces the amount of waste generated. It generally requires a little more effort than the reduction measure. Examples in the lab include the repair and reuse of damaged glassware and participation in chemical exchanges.

Recycle

This waste minimization measure involves the collection and reprocessing of waste materials into new products. Recycling usually requires sorting and segregating waste materials. Recycling diverts waste from disposal, but it requires more labour and resources than waste reduction or reuse alternatives. Some recycling examples for labs include solvent distillation, oil recycling and the collection and reprocessing of paper, corrugated cardboard and glass.

Recovery

This waste minimization measure involves extracting usable energy from waste materials. For example, used oils and solvents can be burned as fuels or used for fuel blending.

The next section of this guide discusses how you can develop and implement a waste minimization plan that incorporates the 4Rs.

Section 2

IMPLEMENTING A WASTE MINIMIZATION PROGRAM

Setting up a waste minimization program is similar to managing any other aspect of your lab. It requires planning and coordinated effort. This section describes the steps involved in implementing a waste minimization program, including:

- Step 1: Getting everyone involved
- Step 2: Taking a look at your waste and waste management practices
- Step 3: Developing a waste minimization plan
- Step 4: Implementing your program
- Step 5: Keeping at it

Each of these steps are described below. An example of a waste audit worksheet is provided in Appendix A to help you collect information and develop your waste minimization plan. You can photocopy and use it directly or modify it to better suit your needs.

Step 1: Getting Everyone Involved

Experience by analytical labs has shown that the success of a waste minimization program relies on the involvement and support of your employees. This includes all employees from lab managers, analysts and technologists to office and administration workers. Everyone has a role to play.

Upper management support is crucial. Many labs have adopted waste minimization policies or guiding principles that are endorsed or signed by management. This demonstrates their commitment to minimizing waste and encourages other staff to be committed too.

To get your program off the ground, you should consider designating a waste minimization coordinator or committee. These people should be enthusiastic, willing participants, and represent key departments or services in your lab (e.g., purchasing, chemical stockroom, sample storage and preparation, lab experiments and office activities). Their responsibilities will include developing and implementing the program, communicating and training staff, and monitoring and tracking successes.

Everyone in your lab should be made aware of the importance of waste minimization and be encouraged to participate. Waste minimization may require some changes in day-to-day operations and some training may be necessary. However, once employees realize how waste minimization can benefit the business and the environment, they will be more committed to your waste minimization program. It is important in a lab environment where hazardous

materials are present, that a waste minimization program does not compromise health and safety or good lab practice.

You should also consider getting your contract services, customers and suppliers involved. For example, your janitorial and maintenance contractors should be aware of your waste minimization goals and initiatives. They may be able to help. Informing your customers of your efforts and seeking further suggestions from them may also be beneficial and necessary for the success of your program. Your suppliers can also play an important role in helping you minimize your waste.

Step 2: Taking A Look

The next step in implementing a waste minimization program is to look at the wastes you generate and your current waste management practices. This task is referred to as a waste audit. It is an important tool that is used to help identify potential waste minimization and cost-saving opportunities-necessary information for developing a waste minimization plan. A waste audit includes determining the quantity and composition of your waste, areas of waste generation, methods of waste disposal, measures for minimizing waste and waste management costs.

A waste audit can be as simple as a quick walk-through of your lab operations and a visual inspection. It can also be very detailed, involving a records review, interviews with staff, a detailed inspection and waste sorting and analysis. You can decide what is best for your lab,

To help you conduct your waste audit, this guide includes a waste audit worksheet to compile the information necessary to identify potential waste minimization opportunities. The waste audit worksheet, which is provided in Appendix A, can be used to record information on the waste quantity, composition and areas of generation as well as waste management practices and waste management costs.

After completing the worksheet you can prioritize your waste streams. This information is important as it helps to identify where you can make the greatest reduction in your total waste generation and it provides you with baseline data to measure your waste minimization successes.

A variety of different types of lab wastes are listed in the worksheet. Some of these wastes may not apply to your lab or you may generate other wastes that are not included. You can modify the worksheet to meet your needs. You can obtain the information for the waste audit worksheet either by visual estimation or by measuring. The latter involves sorting or separating the various waste types and measuring the quantity generated.

Step 3: Developing a Waste Minimization Plan

After conducting your waste audit, review the table in Appendix B to identify potential waste minimization opportunities for your lab (these are discussed in more detail in Section 3). You may want to share your ideas with some of your employees to get their input and suggestions; they may even have additional ideas. The next step is to evaluate and prioritize your potential waste minimization opportunities and develop an action plan.

First, your environmental coordinator or environmental committee should establish realistic waste minimization, program goals and objectives. These goals should be quantifiable and attainable. For example, you may have a goal of a 25 percent reduction in waste generation over the next year with measurable savings in waste disposal costs. Striving towards unrealistic goals will limit your success and discourage employees from participating.

Next you will need to develop criteria to evaluate and prioritize your potential waste minimization opportunities. Some criteria to consider include:

- effectiveness of reducing the amount of waste you generate;
- ease of implementation; and
- potential cost savings.

Measures that result in significant waste reduction, have high potential cost savings, and are relatively easy to implement should be considered first. Then consider options that are more difficult to implement, have less potential savings, or have less impact on the reduction of your waste.

Also, keep the hierarchy of the 4Rs in mind as you evaluate your waste minimization opportunities. Waste reduction and reuse alternatives are generally more favourable from an economic and environmental perspective than recycling and recovery. However, all four help to divert waste from disposal.

Step 4: Implementing Your Plan

After prioritizing your waste minimization opportunities, you can finalize and implement your waste minimization plan. Where possible, you should implement your program in a phased approach. It takes time and effort to successfully implement a program and it is better to start with a few initiatives and expand rather than attempt to undertake too many changes at once.

For each of the prioritized waste minimization opportunities you should develop an implementation strategy as follows:

- Describe the waste minimization initiative.
- Outline the expected benefits of the initiative (e.g., waste reduction and cost savings).

- Identify lab areas or operations that will be affected.
- Develop a list of action items (e.g., operational changes, staff training, bin rental, hauling agreements and identifying a recycler).
- Identify who is responsible for the action items.
- Establish a time frame for completing the action items.

The implementation of your waste minimization program will require some changes to your day-to-day operations. Initially, some organization and effort is required but, once new procedures are implemented properly, they quickly become routine. You will need to inform your employees about the changes and some training may be required. Where possible, keep lines of communication open with employees to encourage participation in your waste minimization program.

Step 5: Keeping At It

As with any other management program, it is important to monitor your progress and track the success of your waste minimization program. Your program is dynamic, and you will need to periodically review and update it. This may require repeat waste audits to assess your waste management and waste minimization practices and identify new waste minimization opportunities. New waste minimization alternatives will become available as technology advances, regulations change and markets develop.

Check periodically with your employees to assess the progress of your program and to solicit new ideas for waste minimization. Consider a suggestion box or survey to obtain employee comments. As well, you may want to provide recognition to employees who suggest effective waste minimization initiatives.

Finally, it is important to keep records of initiatives that you have implemented and the benefits realized. For example, you should track the amount of waste you generate and the amount you divert from disposal. You should also track your waste management costs and cost savings. This information will provide you with a measuring stick to monitor your successes. You may also consider communicating your successes to your customers, which demonstrates your commitment to the environment.

Section 3 WASTE MINIMIZATION OPPORTUNITIES

This section of the booklet provides you with information on specific waste minimization opportunities for analytical labs in Alberta. These include ways to reduce the quantity of waste you generate and ways to reduce its hazard potential. The list of opportunities provided here may not be exhaustive and you may think of other options. Additional information on waste minimization opportunities may also be obtained from some of the resource contacts provided in Section 6 of this booklet.

Waste minimization opportunities are presented in this section according to activity and the 4Rs classifications. This same information is also summarized in Appendix B in a tabular form according to type of waste and should be useful to you as you conduct your waste audit and develop your waste minimization plan.

Table 1 - Activities Generating Waste

Activity	Wastes Generated
Purchasing and Inventory . Shipping and receiving . Sample storage . Chemical/reagent storage	. Packaging waste (e.g., cardboard, Styrofoam) . Unused samples . Unused/expired chemicals . Spills
Office Activities . Data generation . Report preparation . Lunchroom activities . Washrooms	. Computer paper . Office paper . Toner cartridges . Food waste . Containers . Paper towels . Cleaners . Newsprint
Lab Activities . Sample preparation . Analytical procedures . Lab experiments . Pilot studies . Cleanup of analytical areas	. Spent solvents . Acids and bases . Waste reagents and chemicals . Used samples . Reaction products . Labware and supplies . Cleaners

Waste minimization opportunities for each of these activities are discussed below.

Purchasing and Inventory

One of the first steps in reducing excess consumption and wastage of materials and products is to review your purchasing and inventory practices. You will find that changes in some of these practices can reduce the amount of materials you consume and the amount of waste you generate. In addition, cost savings may result by reducing the amount of chemicals wasted due to expiry or unnecessarily high inventories. For example, consider the following:

- Implement a green purchasing policy that favours environmentally friendly products or products that are less hazardous or toxic. Purchase materials with recycled content where possible. Ask your suppliers for information on available products, and favour suppliers that carry them.
- Implement a centralized purchasing program, and designate someone to be responsible for the inventory. This person should monitor requests for chemicals and ensure that duplicate chemicals are not ordered by different departments or for different projects if stock already exists.
- Order only what is needed, and use a first-in, first-out inventory system. This will prevent storing large quantities of chemicals that may expire before they can be used.
- For chemicals and reagents that are used infrequently or expire quickly, order in the smallest quantity practicable to avoid wasting. However, for frequently used chemicals, order in bulk for a lower unit cost and reduced packaging.
- Keep an up-to-date inventory of all chemicals and reagents, perhaps with a computer-based system. There is software commercially available for computerized inventory systems.
- As part of your inventory review, purge the stockroom of unused or expired chemicals.
- Return unopened and unused chemicals to your supplier.
- Properly store chemicals and reagents to prevent breakage and spills. Smaller bottles and containers tend to break less often or less easily than larger bottles; spillage is less and cleanup is easier and safer for smaller containers.
- Maintain labels on all chemicals to prevent the generation of unknown wastes, which are harder and more expensive to dispose of. Note on the label if the chemical is time- or temperature-sensitive, or requires special handling.
- Encourage suppliers to support waste minimization efforts (e.g., take back packaging).

Office Activities

Office and administrative activities at your lab generate waste. Consider the following waste minimization opportunities:

- Use double-sided photocopies.
- Use the backside of single copies for scrap paper.
- Circulate or post memos and other correspondence.
- Use electronic mail where possible for both internal correspondence and for transmitting analytical and experimental results to clients.
- Use paper products with recycled content; where possible, maximize the post-consumer recycled content.
- Use reusable/refillable toner cartridges for photocopiers and printers.
- Reuse office supplies such as file folders, binders and envelopes.
- Regularly service office equipment to maintain efficiency and prevent wasting materials.
- Recycle office paper.

Lab Activities

Waste from analytical labs is generally more diverse in composition than waste from other industries. Labs typically generate a number of different, small quantity waste streams, many of which are hazardous or potentially hazardous. Waste composition in your lab will depend on the type of services you perform. Examples of some of the wastes that may be generated in the lab are shown in Table 2.

The following sections outline some of the waste minimization opportunities available for reducing the quantity and hazard potential of wastes generated from lab activities. Keeping the hierarchy of the 4Rs in mind, reduction and reuse opportunities are presented first, followed by recycling and recovery. This information is also presented in tabular form in Appendix B by type of waste stream.

Table 2
Types of Wastes Generated by Analytical Labs

Waste Category	Examples of Wastes	Hazardous or Potentially Hazardous
Halogenated solvents	Methylene chloride, freon, carbon tetrachloride. chloroform	Yes
Nonhalogenated solvents	Xylene, acetone, toluene, methanol, isopropyl alcohol	Yes
Unused/expired chemicals	Chemicals and reagents required for sample preparation, analysis, experiments or standards	Possibly
Inorganic acids and bases	Nitric acid, sulphuric acid, acetic acid, sodium hydroxide, potassium hydroxide	Yes - if concentrated No - if dilute
Samples	Solid, liquid, soils, water, hydrocarbons	Possibly
Waste chemicals/ reagents and reaction products	For sample preparation, analysis and experiments; may be toxic (heavy metals, cyanide)	Possibly
Used oil	Lubricating oil from rotating equipment or vacuum pumps	Yes
Radioactive waste	Radioactive ore samples	Yes
Biohazardous waste	Tissue samples, cultures	Yes - unless sterilized
Lab supplies and equipment	Disposable gloves, pipettes, wipes, broken glassware	Possibly - if contaminated
Paper	Office paper, computer paper, mixed paper, newsprint	NO
Cardboard	Corrugated boxes and inserts from packaging	No
Plastic	Sample containers, moulded and chipped Styrofoam	Possibly - if contaminated
Glass	Sample containers. chemical and reagent containers and glassware	Possibly - if contaminated
Wastewater (to sanitary sewer)	Water from washing and rinsing, cooling water. water samples, chemical reaction products	Generally not
Air emissions	Air samples, gas samples, volatile emissions from fume hoods	Possibly

Reduction Opportunities

Because reduction is the preferred waste minimization alternative, you should consider these opportunities first. This benefits the environment and saves you money by reducing your consumption and wastage of materials and products. Waste reduction can be considered during experimental planning. Proper choice of experimental methods, analytical equipment, and reagents can significantly reduce the amount of waste generated, the hazards associated with the waste, or both. Keep in mind, however, that any changes in methods or procedures should not compromise health and safety or good lab practices. Some reduction opportunities for you to consider are as follows:

- Consider alternative analytical methods that use less hazardous chemicals or no chemicals and, therefore, produce less waste. For example, consider supercritical solvent extraction as an alternative to conventional extraction. Some labs are attempting to phase out the use of mercury, which is present in many reagents and catalysts. Because most labs are required to follow standard methods, opportunities for method substitution may be limited. However, keep up to date with new standard methods that are being developed and tested.
- Substitute less hazardous or less toxic chemicals for hazardous chemicals where possible. For example, replace chlorinated solvents with non-chlorinated solvents, substitute toluene for benzene, and minimize the use of chromic acid as a glass cleaner by substituting a commercially available alternative.
- Segregate waste streams to prevent non-hazardous waste from mixing with hazardous waste. This will reduce the amount of hazardous waste to be disposed of, as well as prevent the contamination of potentially reusable or recyclable streams.
- Maintain labels on reagent and reaction products to prevent the generation of unknown waste, which is expensive to manage and dispose of. Less effort is required to do this than to analyze an unknown solution so it can be categorized for disposal.
- Where possible, reduce the scale of experiments (e.g., microscale) or run tests on smaller samples. This uses fewer chemicals and generates less waste. In addition, smaller samples can be collected.
- Consider returning excess or hazardous samples to your clients for disposal, or charging your clients for disposal. Alternatively, give samples away to employees if appropriate (e.g., fertilizer samples).
- Reduce solvent and acid use in cleaning operations. For example, sonic baths may be used for cleaning difficult glassware instead of chromic acid solutions. Decrease the use of organic solvents for cleaning glassware and rinsing equipment. Eliminate the use of hazardous materials in maintenance operations.

- General consumption of supplies can usually be reduced. Remember, small amounts of waste do add up over time. Where possible, use washable or reusable labware in place of disposable items. Avoid unnecessary or wasteful use of lab supplies. Keep chemicals and reagents covered to prevent evaporation or spills.
- The hazard potential of many wastes generated in the lab can be reduced by on-site treatment. This can be as simple as autoclaving biohazardous wastes or neutralizing strong acids and bases before disposal down the drain. Opportunities for on-site treatment are explored further in Section 4.

Reuse Opportunities

There are many opportunities in analytical labs to reuse labware, lab supplies, and in some cases, lab chemicals. The following reuse opportunities should be considered:

- Repair and reuse damaged specialty glassware (e.g., glassware with curves and bends such as condensers and distillation flasks) rather than throwing it away. Damaged glassware can be sent to a commercial glassblower for repairs. This not only reduces waste, but can save you money. For example, one Alberta lab has found that repair costs are only 25 to 35 percent of glassware replacement costs.
- Reuse sample containers where possible; this may be feasible for repeat or routine analyses with the same client (e.g., surface water samples). This may also be feasible for glass containers that can be properly cleaned.
- Consider waste material exchanges that typically accept properly labeled chemicals or reagents in their original containers. Waste exchanges can be internal for larger organizations or could be organized based on industry sectors or geographical location. Labs should also consider participating in the U of A Chemical Exchange and Alberta Waste Materials Exchange, or a number of other waste exchanges across the country that are in the process of being linked up by computer. Chemical/waste exchanges may provide information on waste exchange contacts, recycling industry contacts, technical assistance on waste reduction methods, etc.
- Explore the possibility of returning unused chemicals to your supplier.
- Where possible, design experiments so that a product from one experiment can be used as a starting material in another experiment. Make sure you label the end products accurately if they are to be stored before reuse.
- Reuse packaging where possible. For example, many labs reuse Styrofoam chips and cardboard boxes for sending clients sample containers. Also, some packaging may be returned to your supplier for reuse.
- Reuse chemical and reagent containers where possible, such as for collecting and storing wastes or for storing other chemicals that are purchased in bulk. Ensure they are compatible with the contents and are properly labeled. Some plastic containers can also be reused as bailers.

Recycling Opportunities

After reduction and reuse, recycling is the next waste minimization measure to consider for your lab. While recycling is generally more labour and resource intensive, it still diverts waste from disposal and it may save you money. This section of the booklet gives examples of specific recycling opportunities for analytical labs in Alberta.

- A key to successful recycling is proper segregation as recyclable materials should be free of contamination from non-recyclable materials. Segregation is most effective at the point of generation.
- Consider using solvents that can be recycled and either recycle them in house or use an off-site service.
- Many solvents such as acetone, dichloromethane, freon, methanol, xylene, toluene and hexane may be distilled inexpensively in house. Lab-size stills designed for solvent recovery can be purchased or can be assembled by lab personnel using standard lab equipment. Very dirty solvent mixtures may have to be sent off-site for disposal.
- Consider off-site commercial recycling for larger volumes of spent solvents and alcohols.
- Paper and cardboard are commonly recycled by analytical labs. Paper shredders are available if confidentiality is an issue. Many paper recyclers also offer shredding services. Toner cartridges are also recyclable.
- Consider glass and plastic recycling. These include chemical and reagent containers and sample containers. Proper cleaning and rinsing is likely required for these materials to be acceptable for recycling.
- If you generate small amounts of recyclable materials, consider a blue box program for the collection of recyclables (e.g., paper, glass, metal, cardboard) or take your recyclables to a municipal drop-off location.
- Used oil from lab equipment (e.g., vacuum pumps or rotating equipment) can be recycled.
- Consider a vermicompost bin for organic food waste from your lunchroom.
- Get information about recycling possibilities from the AEP Recycle Info Line, your local municipality and local haulers or recycling companies. See Section 6 for contacts.

Recovery Opportunities

- Consider sending nonhalogenated spent solvents and other organic wastes off-site to be burned or blended as fuel.
- Collect used oil (from vacuum pumps and rotating equipment) for recycling or fuel blending.

Section 4 ON-SITE TREATMENT OF HAZARDOUS WASTE

Many opportunities are available to treat hazardous wastes to recover useful byproducts or to render them non-hazardous or less hazardous. This is much more environmentally friendly than disposal or dilution of hazardous waste. Not only does this reduce safety concerns with respect to handling the waste, it also reduces disposal costs.

Certain wastes can be made less hazardous by simple treatments in the lab. These treatment methods are often specific to the particular compounds or chemicals involved and are based on their chemistry. A number of excellent reference books are available on specific methods for particular chemicals and waste types. Some of these are included in Section 6 of this booklet. You are encouraged to consult these books as part of your waste minimization program. Some examples of on-site treatment opportunities available to you include:

- Biohazardous waste can be autoclaved to sterilize it. The sterilized waste can then be disposed of in the regular trash.
- Corrosive and reactive wastes can be neutralized before disposal. Neutralization can be done by a simple treatment method requiring a fume hood, personal protective equipment and corrosion-resistant containers and equipment. Waste or surplus dilute acids and bases can be used for neutralizing. Chemicals suitable for neutralization and the associated lab procedures are listed in various reference books.
- The disposal of many heavy metals into landfills in Alberta is prohibited. Some of these metals may be precipitated as salts that may be acceptable for landfill disposal if they are insoluble. Metal precipitation does not completely eliminate disposal requirements but can render some hazardous wastes non-hazardous. The aqueous portion can be used for oxidizing some organic waste streams or be disposed of down the drain. It may also be worthwhile to recover and recycle valuable metals (precious metals).
- Reducing the volume of dilute solutions of inorganic salts can simplify disposal. For example, if an experiment yields a large volume of dilute aqueous solution containing toxic heavy metal ions, the solution can be placed in a large evaporating dish in a fume hood and allowed to evaporate. The remaining residue is packaged and labeled for disposal.
- Mercury and chromium salts may be recovered from the solutions remaining from COD tests.
- For mixed wastes, phase separation can often be used to separate the hazardous portion from the non-hazardous portion. For example, toxic precipitates can be settled or filtered out from a slurry for separate disposal, or nonaqueous organic material can be separated from the aqueous phase.

- Oxidation reactions may be applicable to many substances, including polycyclic aromatic hydrocarbons, nitrosamides, aromatic amines, cyanides and sulphides. Many oxidants may be suitable for this purpose, including sodium hypochlorite and hydrogen peroxide. (Check with available references for details.)
- Strong oxidizing agents such as potassium permanganate, sodium chlorate and calcium hypochlorite can be reduced before discarding to the sanitary sewer. This may be done with an aqueous solution of sodium bisulfite.
- Acidic solutions of potassium dichromate are widely used for cleaning glassware. This material is hazardous and should not be disposed of down the drain. Non-hazardous, insoluble chromium hydroxide can be formed by reduction of the dichromate with sodium thiosulphate solution. Alternatively, there are other less hazardous glass cleaners available.
- Appropriate personal protection, such as gloves, goggles, lab coats, etc., should be worn during on-site treatment of wastes. It may be necessary to conduct treatment reactions under a fume hood. Make sure that you understand the chemistry involved in the particular treatment reaction to avoid an unsafe situation. Also, check the reference materials for details on treatment processes.

Section 5 PROPER WASTE DISPOSAL

After implementing your waste minimization program, you will still have some waste that must be disposed of. For analytical labs, this waste will be made up of both non-hazardous and hazardous or potentially hazardous materials. This section outlines some of the environmental and health and safety regulations governing hazardous waste management, and briefly reviews proper waste storage, handling and disposal procedures. Disposal practices for non-hazardous wastes are also briefly described.

Applicable Regulations

Because of the complex nature of lab wastes, there are several regulations that lab workers should be aware of. These include federal, provincial, and municipal regulations. This section summarizes the regulations that may be applicable to the operations of your analytical lab. Further information can be obtained from the references listed in Section 6 of this report.

The Alberta Environmental Protection and Enhancement Act (EPEA) is applicable to the management of many wastes generated by analytical labs. In particular, the Waste Control Regulation deals with the storage, collection, transportation, treatment and disposal of hazardous waste and hazardous recyclables. This regulation also describes how to tell if a material is hazardous, how hazardous wastes should be handled, how long hazardous wastes can be stored and exemptions for small quantities of waste. For more information contact the Industrial Wastes Branch of AEP.

The Alberta Occupational Health and Safety Act, Chemical Hazards Regulation, was developed to ensure the health and safety of workers coming into contact with hazardous substances. This includes procedures to minimize exposure, the duties of employers, and mandatory training for employees. Workplace Hazardous Material Information System (WHMIS) training is required under this Act. For more information, contact the Alberta Environmental Health Services or your local health board.

The Alberta Fire Code regulates storage and handling requirements for several groups of substances used in analytical and research labs, including flammable and combustible liquids, compressed gases, reactive, radioactive, corrosive, oxidizing, poisonous and infectious substances. The Act contains provisions regarding types and size of storage containers, maximum storage quantities, spill control, fire suppression system requirements and ventilation requirements. For more information, contact your local fire department.

The Transportation of Dangerous Goods Act and associated regulations (TDGR) contain rules for handling, offering for transport and transportation of

dangerous goods. The Act and regulations provide criteria for classifying dangerous goods; specify packaging, labeling and manifesting requirements; and list the safety requirements for handling, offering for transport and transportation of dangerous goods. TDGR also contains provisions regarding safety requirements for personnel training and requirements associated with accidental spill and loss reporting and inspection. For more information, contact Alberta Public Safety.

Municipalities may also have regulations restricting the disposal of solid and liquid wastes. Municipal landfills may prohibit or restrict the disposal of certain materials. Sewer use bylaws may restrict the discharge of prohibited materials such as flammable, corrosive, odourous or toxic materials to the sanitary and storm sewer systems. The disposal of metals and organic chemicals is often restricted. Contact your municipality for more information.

Radioactive wastes are regulated by the federal government under the Atomic Energy Control Act. The production, importation and management of chlorinated fluorocarbons (CFCs) are regulated under the federal Hazardous Products Act.

Handling and Storing Hazardous Wastes

Hazardous wastes that cannot be further treated or eliminated must be stored and managed in a way that ensures the safety of lab workers and meets the requirements of all applicable regulations and guidelines. There are a number of reference books and materials that address hazardous waste handling and storage. Given below are some suggestions for safe storage and handling practices for you to consider in your lab. For more information, refer to the references in Section 6 of this guide.

- Familiarize yourself with applicable legislation and regulations and be aware of handling and storage requirements for specific materials, e.g., corrosives, flammables, reactive materials, toxic compounds, etc.
- Segregate hazardous wastes based on compatibility, particularly ignitables from oxidizers or sources of ignition. As well, segregate chlorinated solvents from nonchlorinated solvents.
- Store hazardous wastes in compatible containers.
- Keep containers closed to prevent spills and vapor releases.
- Properly identify and label wastes according to proper waste management practices to ensure employee safety and transportation safety.
- Provide an appropriate storage area for hazardous wastes. Consider secondary containment, spill control measures, proper ventilation and fire or explosion protection, if necessary. Inspect storage areas routinely to detect and prevent spills or releases.

- Prevent hazardous wastes from entering storm drains or drains to the sanitary sewer.
- Avoid accumulating hazardous wastes for extended periods. Be aware of the maximum allowable accumulation time specified in the regulations.
- Provide appropriate training for employees. This may include WHMIS, health and safety, or hazardous waste management training.
- Ensure that proper records are kept for hazardous waste storage and transport, e.g., manifests.
- Ensure proper transport of hazardous chemicals and wastes in the lab to prevent spills and other incidents.

Hazardous Waste Disposal

Hazardous lab wastes that cannot be recycled or rendered non-hazardous should be disposed of in a safe and responsible manner. In Alberta and most jurisdictions, hazardous waste must be disposed of at an approved facility. Examples of approved facilities may include hazardous waste incinerators or landfills approved to accept hazardous waste. Before you dispose of your hazardous waste, check to ensure that the disposal facility is approved to accept your waste.

Hazardous waste disposal facilities may accept wastes in a variety of forms, including lab packs, containers such as pails or drums, or in bulk. Lab packs are one of the most common packaging methods for hazardous wastes from labs. Small containers are packed together in a drum according to hazard class with an absorbent material added to cushion and absorb any leaks or spills. The advantage of lab packs is that they are relatively simple and safe to use. The main disadvantage is that they are generally a more expensive disposal method as there is excess void space in the drum.

An alternative to lab packing is bulking wastes, which requires the removal of materials from their original containers. Bulking is more time consuming and more attention must be paid to compatibility. However, the advantage of bulking wastes is that it can reduce the total cost of disposal through a more efficient use of drum space.

Wastewater Disposal

Previously, it was a commonly accepted practice in most labs to dispose of liquid wastes and wastewater indiscriminantly down the drain. However, this is no longer the case. Most lab drains are connected to a sanitary sewer system and the effluent eventually flows to a sewage treatment plant. Concerns about chemicals that can create hazards such as fire, explosion, air pollution and water pollution, or can corrode the system piping or upset the operation of the sewage

treatment plant have meant that disposal of some materials is no longer acceptable. Wastewater disposal practices must comply with applicable regulations, such as the local sewer bylaw, and will depend on characteristics and capabilities of the local wastewater treatment plant.

Some suggestions for the disposal of wastewater are:

- Drain disposal should only be to the sanitary sewer and not to the storm sewer. Wastes disposed of down manholes or catchbasins enter the storm sewer system and are discharged directly to rivers and lakes. These wastes receive no treatment.
- Familiarize yourself with the municipal sewer bylaws. This is your best resource for determining if a chemical is suitable for drain disposal. For chemicals that are not explicitly listed, contact your municipal public works department or, if in doubt, assume a material is hazardous and do not dispose of it down the drain.
- The quantity of chemicals disposed of down the drain should be relatively small and highly diluted with water. For example, dilute solutions of inorganic salts may be acceptable for disposal down the drain.
- In addition to being compatible with the sewer system and treatment plant (as stated in the municipal regulations), there is a need for compatibility with other chemicals entering the drain system. Incompatible chemicals can mix in your lab's plumbing or in the sewer pipes and become corrosive or toxic.
- As described earlier, consider pretreatment of liquid wastes before disposing of them down the drain. For example, acids and bases should be neutralized before they are disposed of.

Landfill Disposal

Conventional landfill disposal is only appropriate for non-hazardous waste. The disposal by landfilling of suitable solid hazardous waste requires, in Alberta, strict compliance with specific landfill design requirements.

Section 6 WHERE TO GET MORE INFORMATION

This section provides you with a list of resources and sources of information on waste management and waste minimization for analytical labs in Alberta. Information on specific businesses providing waste minimization services are not included because this information quickly changes. However, you will find that many of the organizations and resources listed below maintain up-to-date listings of such businesses.

Government Agencies

Alberta Environmental Protection, Action on Waste
Alberta's Recycle Info Line
l-800-463-6326
You can obtain information on waste minimization opportunities in Alberta as well as phone numbers of businesses providing waste minimization services throughout the province. Several guidance publications have been published by Alberta Environmental Protection that are available to the public free of charge.

Alberta Environmental Protection, Action on Waste
(403) 427-5838 (Edmonton)
To be connected toll-free call 310-0000 and ask for 427-5838.
You can obtain guidance and technical assistance on waste minimization opportunities in the province.

Alberta Environmental Protection, Library
(403) 427-5870 (Edmonton)
To be connected toll-free call 310-0000 and ask for 427-5870.
Alberta Environmental Protection has an extensive library that includes information on waste management and waste minimization in the province. Access to these library services is available to the public free of charge.

Alberta Environmental Protection, Industrial Wastes Branch
(403) 427-5847 (Edmonton)
To be connected toll-free call 310-0000 and ask for 427-5847.
The Industrial Wastes Branch can provide you with information on applicable hazardous waste regulations and requirements and how to properly manage your hazardous wastes.

Alberta Health, Environmental Health Services
(403) 427-2643 (Edmonton)
To be connected toll-free call 310-0000 and ask for 427-2643.
Alberta Health can provide you with information on applicable health and safety regulations that affect waste management and waste minimization in analytical labs. You can also contact your local health board for this information and any other specific policies that may apply.

Alberta Public Safety Services, Compliances Information Centre
l-800-272-9600

Alberta Public Safety Services can provide you with information on the Transportation of Dangerous Goods Act and associated regulations with regard to classifying dangerous goods, packaging, labelling and manifesting requirements.

Alberta Waste Materials Exchange, Alberta Research Council
(403) 450-5050 (Edmonton)

The Alberta Waste Materials Exchange is an information clearinghouse for reusable waste materials that are available and wanted in the province. It publishes a quarterly bulletin that provides listings of these materials as well as services.

Recycling Council of Alberta
(403) 287-1477 (Calgary)

The Recycling Council of Alberta can provide information on recycling opportunities in the province.

City of Edmonton, Waste Management Branch - Waste Hot Line
(403) 496-5678 (Edmonton)

You can obtain information from the Waste Hot Line regarding waste management and waste minimization opportunities for your lab. The Waste Management Branch also operates the Commercial Waste Reduction Program, which assists Edmonton businesses in minimizing their waste.

City of Calgary, Solid Waste Services Division - Recycling Hotline
(403) 277-7770 (Calgary)

You can obtain information from the Recycling Hotline on recycling opportunities for your lab. If you want general information on waste management and waste minimization initiatives in the City of Calgary, you can also call the hotline.

Other Organizations and Associations

University of Alberta, Chemistry Department
Chemical Exchange Program
(403) 492-7484 (Edmonton)

The University of Alberta Chemistry Department operates a chemical exchange program that is available to both university and non-university personnel. For more information on the program and the types of chemicals that are accepted, contact the Chemistry Department.

Environmental Services Association of Alberta
(403) 439-6363 (Edmonton)

The Environmental Services Association of Alberta (ESAA) is an industry association whose members include waste management companies and recyclers. ESAA publishes a directory annually that includes a listing of members and their services.

Reference Materials

There are a number of useful reference materials that address lab waste minimization techniques, waste management and on-site treatment of hazardous waste. Some of these references are listed below; however, the list is not exhaustive and other references are available.

- American Chemical Society. *The Waste Management Manual for Laboratory Personnel.* Washington, D.C. April 1990.
- Armour, M.A. *Hazardous Laboratory Chemicals Disposal Guide.* CRC Press. 1991.
- ASTM. *Standard Guide for Disposal of Laboratory Chemicals and Samples.* D 4447-84. 1990.
- American Chemical Society. *Laboratory Waste Management: A Guidebook.* Washington, D.C. 1994.
- National Research Council. *Prudent Practices for Disposal of Chemicals from Laboratories.* Washington, D.C. National Academy Press. 1983.

Appendix A WASTE AUDIT WORKSHEET

The attached waste audit worksheet can help you compile information about the types and quantities of waste you generate, where these wastes are generated, how they are managed, and the cost of waste management. To obtain the necessary information, you may need to:

- Conduct a walk-through of your lab.
- Talk to your employees or contractors.
- Review business records such as waste hauling and disposal contracts and invoices.
- Sort and measure various waste streams.

You can decide on the appropriate level of detail for conducting a waste audit at your lab.

Worksheet Instructions

Some instructions and things to keep in mind when completing the waste audit worksheet are provided below.

General Information

This section of the worksheet provides general information that is useful for future reference. It includes the name of your lab and its location, which is important if you have more than one location. It also includes the date that the waste audit worksheet was completed and by whom.

Waste Quantification and Characterization

This table summarizes information about the waste you generate and how you manage that waste. Several different categories and subcategories of waste are included for consideration. They may not all apply to your lab, or there may be other wastes that you wish to add to the table. You can modify the table to meet your needs.

Areas Generating Waste. Identify the areas of your lab that generate each waste type (e.g., purchasing and inventory, office activities and lab activities).

Waste Quantity Generated. The quantity of each waste type generated can be expressed as weight or volume, or a percentage of the total waste stream. If you express quantity as a percentage, be sure to indicate if it is on a weight or volume basis. If you express the quantity as a weight or volume, you will also need to specify the time period (e.g., kg/d, tonnes/week, yd^3/month). You can obtain waste quantity information by visual observation, waste hauling and disposal information, and/or sorting and measuring your waste. The value you record should correspond to the total amount of waste generated, whether or not it is disposed of.

Waste Quantity to Disposal. This is the quantity of waste generated that is disposed of in landfills, sanitary sewers, or off-site hazardous waste disposal facilities. Quantities should be expressed in the same units as those in column (3).

Waste Quantity Diverted. This is the quantity of waste that is diverted from disposal (i.e., landfill, sewer, off-site disposal). For example, you may reuse or recycle certain wastes. Quantities should be expressed in similar units to those in columns (3) and (4). If you express quantity as a percentage, be sure to indicate if you mean a percentage of the total waste or of the specific type of waste.

Waste Diversion Measures. Make a note of the measures taken to divert each type of waste stream from disposal. Waste diversion measures may include on-site reuse, off-site reuse, recycling, on-site treatment, etc.

Waste Management Costs. Record your waste management costs. This includes waste disposal costs (bin rental, hauling fees, landfill tipping fees, hazardous waste disposal fees) and waste diversion costs such as recycling (bin rental, hauling costs, revenue generated). You may want to express these costs on a similar time basis as used in columns (3), (4), and (6).

Potential Waste Minimization Opportunities. As you work through your waste audit, you will identify potential waste minimization opportunities for various types of waste. You may want to make a note of them here. For ideas on waste minimization opportunities see Section 3 of this booklet or the summary table in Appendix B.

APPENDIX A

Table A-1 - Analytical Labs
Waste Audit Worksheet

I. General Information:

Laboratory name and location: _____

Date(s) of waste audit: _____

Person(s) conducting audit: _____

II. Waste Quantification and Characterization

(1) Waste Type	(2) Area(s) Generating Waste	(3) Quantity Generated (wt/vol/%)	(4) Waste Quanity to Disposal (wt/vol/%)	(5) Waste Quantity Diverted (wt/vol/%)	(6) Waste Diversion Measures	(7) Waste Managements Costs	(8) Potential Waste Minimization Oppotunities
Chemicals: • Solvents • Inorganic acids and bases • Unused/expired reagents • Waste reagents and reaction products • Others (specify)							
Samples: • Hazardous • Non-hazardous							
Used Oil							
Lab Equipment and Supplies • • •							
Paper waste: • Corrugated cardboard • Office paper • Computer paper • Other paper (specify)							

Plastic waste: • **Sample** containers • **Chemical** containers • **Beverage** containers • **Film, wrap,** bags • **Other** (specify)							
Metal waste: • Beverage containers • **Other metal** containers/cans • **Other metal** (specify)							
Glass waste: • **Sample** containers • **Chemical** containers • **Beverage** containers • **Broken** glassware • **Other glass** (specify)							
Biohazardous waste: • Specify							
Radioactive waste: • Specify							
Wastewater: • **Washing and** rinsing • **Cooling** water • **Reaction** Products • **Other** (specify)							
Other wastes (specify) • • •							
Total waste							

Appendix B

WASTE MINIMIZATION OPPORTUNITIES SUMMARY TABLE

The enclosed table summarizes a number of waste minimization opportunities that may be applicable to your lab. The opportunities provided are listed for different lab waste categories. For more detailed information on these opportunities, see Sections 3 and 4 of this booklet. Consider these opportunities when completing your waste audit and developing your waste minimization plan.

APPENDIX B

Waste Minimization Opportunities Summary Table

Waste Category	Examples	Characteristics	Minimization Opportunities
Halogenated solvents	Methylene chloride Chloroform Freon Carbon tetrachloride Tetrachloroethylene 1,1,1 -trichloroethane Chlorobenzene Ethyl bromide	. Many halogenated solvents and hydrocarbons are toxic . Generally low solubility in water . Solvents may be ignitable . Special handling required	. Properly segregate halogenated solvents from nonhalogenated solvents . Provide appropriate storage for waste solvents (e.g., proper containers, away from ignition sources, segregated from oxidizers) . Consider recovering and recycling (on-site or off-site) . Lab pack and dispose of using a licensed waste management firm . Bulk and dispose of using a licensed waste management firm . Avoid disposal down the drain
Nonhalogenated solvents	Toluene Acetone Methanol Isopropylalcohol Xylene	. Many nonhalogenated solvents and hydrocarbons are toxic . Solvents may be ignitable . Special handling required	. Properly segregated halogenated solvents from nonhalogenated solvents . Provide appropriate storage for waste solvents (e.g., proper containers, away from ignition sources, segregated from oxidizers) . Consider recovering and recycling nonhalogenated solvents (on-site or off-site distillation) . Consider reusing solvents where possible (if high purity not a concern) . Lab pack and dispose of using a licensed waste management firm . Bulk and dispose of using a licensed waste management firm . Avoid disposal down the drain . Consider sending off-site for fuel blending and burn for heat recovery . Reduce the amount of solvent used for rinsing
Unused/expired chemicals	Chemicals and reagents used for sample preparation, analyses, experiments or standards	. May or may not be hazardous depending on nature of chemical	. Only purchase chemicals that are needed . Check current inventories before purchasing . Purchase the smallest amount practicable: work with suppliers to take back unused chemicals . Properly maintain labels to avoid generating unknown wastes . Participate in chemical or waste exchanges
Inorganic acids and bases	Nitric acid Sulfuric acid Hydrochloric acid Acetic acid Potassium hydroxide Sodium hydroxide	. Hazardous in concentrated form . Non-hazardous in dilute form	. Dilute weak acids and bases before disposing down the drain . Neutralize strong acids and bases before disposing down the drain . Properly manage concentrated acid and base wastes; manage as hazardous waste
Samples	May be solid or liquid, hazardous or non-hazardous	. May be hazardous or non-hazardous . Some constituents or characteristics may be unknown	. Determine to the extent possible the characteristics of the sample . Properly store and manage hazardous samples . Dispose of non-hazardous samples down the drain (liquid) or in the trash (solid) . Consider returning samples to your clients (particularly hazardous samples) . Consider charging clients for hazardous waste disposal . Give away fertilizer samples to employees

(continued...)

.(... continued) APPENDIX B

Waste Category	Examples	Characteristics	Minimization Opportunities
Waste chemicals, reagents and reaction products	From sample preparation, analyses and experiments	. May be hazardous or non-hazardous depending on nature of chemical . Reaction products may be unknown	. Purchase non-hazardous or less hazardous chemicals where possible . Properly store chemicals to prevent spills and breakage of containers . Use opened containers of chemicals before opening new ones . Consider method substitution to replace hazardous chemicals . Use reaction products from one experiment as a feed material for another
Used oil	Lubricating oil from rotating equipment and vacuum pumps	. May be hazardous	. Segregate from other wastes . Send off-site for recycling . Send off-site for fuel blending and burning for heat recovery
Lab equipment and supplies	Disposable gloves, pipettes, wipes, broken glassware	. May be hazardous if contaminated but generally non-hazardous	. Avoid the use of disposable supplies where practical . Wash and reuse supplies and containers where possible . Avoid contamination where possible
Paper	From office activities and report generation; computer paper, office paper, newsprint	. Non-hazardous	. Use E-mail internally or to send analytical reports to clients to reduce paper waste . Reuse paper where possible . Recycle paper
Cardboard	Corrugated boxes and inserts from packaging	. Non-hazardous	. Reuse cardboard boxes and inserts for shipping sample containers . Recycle cardboard
Plastic	Sample containers, molded and chipped Styrofoam	. Non-hazardous unless contaminated	. Reuse Styrofoam chips where possible . Return Styrofoam to your chemical supplier . Consider reusing plastic containers from chemicals . Consider reusing plastic sample containers (where possible) . Recycle plastic containers (provide proper cleaning)
Glass	Sample containers, chemical and reagent containers and glassware	. Non-hazardous unless contaminated	. Repair and reuse expensive and intricate glassware . Reuse sample containers where possible . Reuse chemical and reagent containers; proper washing required . Recycle glass where possible (provide proper cleaning)
Biohazardous waste	Tissue samples, microbiological cultures	. Hazardous unless sterilized	. Sterilize in an autoclave . Dispose of sterilized waste in the trash
Radioactive waste	Radioactive ore samples (uranium)	. Hazardous	. Segregate from other wastes . Properly store and dispose of . Return samples to client
Wastewater	Water from washing and rinsing, cooling water, water samples, chemical reaction products	. Generally non-hazardous but may contain hazardous constituents (toxic metals, organics, etc.)	. Be aware of applicable regulations and bylaws . Neutralize acids and bases before disposing of down the drain . Reduce strong oxidizing agents before disposing down the drain . Precipitate out metals before disposing of down the drain . If in doubt, assume a waste is potentially hazardous and don't dispose of down the drain

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