1. Purpose

Waste Minimization (WM) and Pollution Prevention (P2), efforts can save money as well as protect our environment. When materials and products are used more effectively, resources are conserved and there is a reduction in waste generation, and pollution overall. A WM plan can strengthen existing health and safety programs in the laboratory by exposing personnel to smaller amounts of hazardous chemicals and wastes generated. Ultimately, a WM plan is a regulatory requirement. The Environmental Protection Agency (EPA) states in 40 CRF 262.27(b) that a small quantity generator must make a good faith effort to minimize the waste generation and select the best waste management method that is available to us and that we can afford.

WM should be viewed as part of total quality management and should not compromise the need to meet health and safety standards or good laboratory practices. 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 stricter, WM will become synonymous with good business sense.

There are several avenues to accomplish WM. This plan will take you through the components of WM and techniques that can be followed to achieve WM.
2. Scope

The scope of the WM Plan covers all individuals that are generating any waste at Duquesne University, whether the waste is hazardous, non-hazardous, biological, or radioactive.

3. Hazardous Waste Overview

According to 40 CFR 261, the EPA specifies waste as hazardous if they appear on one of four lists (P-list, K-list, F-list, or U-list) or exhibit a particular hazardous characteristic. For laboratories, the most relevant listings are those for spent solvents (a portion of the F-list) and discarded commercial chemical products (known as P- and U-lists). Spent solvents on the F-list are designated by the codes F001, F002, F003, F004, and F005 and include common solvents such as acetone, methanol, methylene chloride, toluene, and xylene. The P- and U-lists apply to unused, discarded commercial chemical products with a sole active ingredient on one of the two lists. Expired or unused laboratory chemicals are often P- or U-listed wastes.

Two classes of wastes: listed and characteristic.

3.1 Listed wastes are generated from specific processes or contain a hazardous constituent. An example would be any spent halogenated wastes – methylene chloride or trichloroethylene. Some of these listed wastes are considered “acute hazardous wastes”. Acute hazardous wastes are very toxic and can be fatal to humans in small amounts.

3.2 Characteristic wastes demonstrate having certain hazard characteristics. The EPA has test procedures to identify such characteristics. They include the following:
   a. Ignitability – generally liquids with a flashpoint below 140°F.
      a. Flammable Liquids – alcohols, benzene, toluene, acetonitrile
      b. Oxidizers – nitrates, perchlorates, bromates, permanganates, perox, iodates
      c. Organic Peroxides – benzyol peroxide, cumene hydroperoxide, ethyl ketone peroxide
   b. Corrosivity – aqueous solutions with a pH ≤ 2 or ≥ 12.5.
      a. Inorganic Acids – hydrochloric acid, sulfuric acid, nitric acid, perchloric acid, phosphoric acid
      b. Organic Acids – formic acid, lactic acid
      c. Bases – hydroxide solutions, amines
   c. Reactivity – unstable, explosive, or water reactive.
      a. Sulfides and cyanides
      b. Peroxide Formers – ethers, potassium amide, sodium amide, tetrahydrofuran
      c. Alkali Metals – sodium, potassium, lithium
      d. Dinitro- and Trinitro- Compounds – picric acid
      e. Carbonyl Compounds
      f. Isocyanates
      g. Perchlorate Crystal Formers – perchloric acid
   d. Toxicity – contain one or more of 40 regulated toxic constituents (any detectable amount of these chemicals must be identified as hazardous waste).
      a. Eight Heavy Metals
b. Ten Pesticides

\[\text{c. Twenty Two Organic Chemicals}\]

Radioactive and biological wastes are not included as a characteristic waste. These wastes fall under different regulations.

Waste profiling is the determination of a waste. This is generally done by the scientist who is generating the waste. They are primarily responsible for identifying the components in the waste stream. The scientist is responsible for compiling a list of all known or suspected hazardous components in their waste.

The goal of waste minimization is to reduce the environmental impact, as well as the overall cost of waste management. This is accomplished through emergency preparedness and following waste minimization procedures.

Accidents can happen. It is a matter of how somebody responds to that accident. Incidental spills, or small scale spills, may not pose a threat to the health and safety of personnel. An incidental spill is that consisting of less than one liter of liquid. In the Chemical Hygiene Plan (CHP), the best procedure to follow to clean up the spill will be described. For larger spills, the spill response team should be contacted.

Waste management is a way to protect the environment by adopting and practicing procedures that minimize the amount or toxicity of wastes generated.

4. Components of the Waste Minimization Plan

There are several components involved in making a WM plan work. First there has to be upper management support. From the upper management support, there should be an overall employee participation. Most of that will be gained through open communication, trainings, and waste audits, as discussed below.

4.1 MANAGEMENT (Faculty) SUPPORT AND EMPLOYEE (TA’s, RA’s, Post Docs, etc.) PARTICIPATION

A clear commitment by senior management through policy, communications, and resources, to WM is essential to earning the dedication of all employees. For this to happen, a formal policy statement must be drafted and adopted. The purpose of this statement is to reflect the laboratories’, departments’, and ultimately the University’s commitment and attitude toward protecting the environment, minimizing or eliminating waste, and reuse or recycling of materials. Creative, progressive, and responsible leadership will serve to develop environmental policy; however, the total employee workforce will need to be involved.

4.2 TRAINING

Training employees on the proper way to use, handle, and store hazardous materials can reduce the amount of waste generated. The employee will learn how to use proper amounts thus reducing enormous amounts of generated waste. Proper handling techniques will reduce leaks.
and spillages that are a source of waste. The training will also give the employee self-assurance that he or she is valued by the university.

4.3 WASTE AUDITS
Conducting waste audits is a good way to keep up on what is happening within the laboratory setting. Waste audits can provide a systematic and periodic survey of the university’s operations and can identify additional areas of potential waste reduction. A waste audit includes the identification and inventory of hazardous waste and the sources of these wastes, the prioritization of various waste reduction actions to be undertaken, the evaluation of technical solutions, economically and ecologically feasible approaches to WM, the development of an economic comparison of WM options, and the evaluation of their results.

5. Waste Minimization Techniques

There are six main techniques to minimize waste generation. They include:

5.1 Good Housekeeping,
5.2 Separation and Segregation,
5.3 Recycling and Reuse,
5.4 Inventory, Purchasing Controls and Source Reduction,
5.5 Substitution, and
5.6 Microscale Chemistry/Process Modification.

5.1 GOOD HOUSEKEEPING
Good housekeeping is the simplest way to minimize waste generation.

Examples:
- Avoid spilling or dripping chemicals that would need to be cleaned up.
- Use only unbreakable containers, when possible.
- Always use carts to transport chemicals.
- Use secondary containment devices to contain spills.
- Always label all containers with the contents and date.

5.2 SEPARATION AND SEGREGATION
Keep hazardous wastes separate from other wastes – no mixing. Do not mix hazardous and non-hazardous wastes – segregate the waste streams. For example, halogenated and non-halogenated wastes should be kept separate. Mixing of biological and hazardous wastes or radioactive and hazardous wastes is very expensive to dispose of.

The table below shows the hierarchy of storage groups; this table can be used when separating incompatible chemicals.
### Hierarchy of Storage Groups

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>2. Explosive</td>
<td>E1</td>
<td>12. Flammable Liquid</td>
<td>F1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Herbicides</td>
<td>P1</td>
<td>13. Oxidizers</td>
<td>R1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. All other Pesticides</td>
<td>P2</td>
<td>14. Pyrophoric</td>
<td>R4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Flammable – Toxic Gas</td>
<td>G1</td>
<td>15. Waste Reactive</td>
<td>R3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Flammable – Non Toxic Gas</td>
<td>G2</td>
<td>17. Corrosive Acid</td>
<td>C1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Acetylene Gas</td>
<td>G7</td>
<td>18. Corrosive Base</td>
<td>B1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Chlorine Gas</td>
<td>G5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table below demonstrates what groups can be stored together

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>C1</td>
<td>B1</td>
<td>R3</td>
<td>G6</td>
<td>G7</td>
</tr>
<tr>
<td>E1</td>
<td>R2</td>
<td>T1</td>
<td>R1</td>
<td>R4</td>
<td>P1, P2</td>
</tr>
<tr>
<td>G1</td>
<td>G1</td>
<td>G1</td>
<td>G1</td>
<td>G1</td>
<td>G1</td>
</tr>
</tbody>
</table>

### 5.3 RECYCLING AND REUSE

Recycling can take several forms. One is the actual “recovery” of a “used” substance (i.e. solvents). Once recycled, these materials, even though they may be less pure, can be used in other processes or experimentation where high quality is not an issue. Another means of recycling is to develop an “orphan” chemical system whereby unneeded chemicals from one department can be given to another lab or department. Practice recycling whenever possible.

Examples:
- Mixtures of used alcohols can sometimes be used in preparing standard solutions.
- Used nitric and sulfuric acids from ion exchange columns can sometimes be used as a pre-cleaning rinse on another column.

### 5.4 INVENTORY, PURCHASE CONTROLS, AND SOURCE REDUCTION

Inventory and purchase controls help reduce the disposal of old, expired chemicals, as well as over ordering items.

Purchasing chemicals in larger containers at an initial lower cost, rather than smaller containers, appears to be a good way to save money. However, consideration of the total costs of such purchases makes it clear this may not be the case. When a large container of a chemical is purchased, often a small quantity is taken out for use and the rest is stored. As a result, partially filled containers accumulate in laboratories and storerooms, and the chemicals – many of which have exceeded safe storage time periods or have unreadable labels – are disposed of as waste.
In a laboratory that has not adequately implemented WM programs, unused chemicals typically constitute 40% or more of the hazardous waste stream generated. Costs incurred as a result of these unneeded chemicals include analysis, storage, packaging, transport, and disposal. When labels are missing or unclear, the cost of having even a small amount of an unknown chemical analyzed prior to disposal will far exceed the purchase prices of an entire container of the materials. Furthermore, long-term storage of unused chemicals increases the risk of accidents. Also, smaller bottles are sturdier than larger ones, so breakage and spill risks are substantially reduced. If bottles do break, there is less spillage, making clean-up safer, easier, and less expensive.

The figure below demonstrates a cost overview per one container of chemical purchased.

There are several ways to control one’s inventory and purchasing. To start, one should conduct a lab clean out. These are necessary to get rid of expired, excess, or unwanted items. Every lab should have a schedule of cleanouts (i.e. each semester, annually). And always access results from previous cleanouts. A more involved control mechanism would be to purchase a system that monitors requisitions to prevent the purchase of hazardous chemicals, for which safer substitutions are available.

Other Examples:
1. avoid over ordering reagents, especially those with a short shelf life;
2. order only the amount needed;
3. make sure all containers are clearly labeled;
4. use older materials first, to avoid expiration;
5. share chemicals and stocks;
6. conduct periodic lab clean outs
The Myth of Buying in Bulk

If 1000 ml of phenol are used...

<table>
<thead>
<tr>
<th>Two 500 ml bottles</th>
<th>One 2500 ml bottle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalog unit cost</td>
<td>7.2 cents/ml</td>
</tr>
<tr>
<td>Purchase cost</td>
<td>$72.00</td>
</tr>
<tr>
<td>Lab pack disposal cost</td>
<td>$ 0.00</td>
</tr>
<tr>
<td>Total cost of the chemical</td>
<td>$72.00</td>
</tr>
</tbody>
</table>

TRUE COST = SUM OF PURCHASE + DISPOSAL + LABOR + LIABILITY + COMPLIANCE COSTS

5.5 SUBSTITUTION

In recent years, most laboratories have minimized waste generation by substituting less hazardous chemicals for more hazardous chemicals. Substitution is a good method to use, which entails substituting a non-hazardous reagent, catalyst or solution for a hazardous one. An example would be how acid cleaning solutions can be replaced with detergents or ultrasonic cleaning systems. However, in the academic setting, identifying viable chemical substitutes may be difficult. Contact with colleagues or chemical suppliers may be useful in obtaining information on potential substitutions. Another resource of information would be the Integrated Solvent Substitution Data Systems (ISSDS), which can be found at http://es.epa.gov/issds/index.html.

Below are some examples of common substitutions.

Examples:

1. Cyclohexane can often substitute for the more toxic benzene;
2. Hydrocarbon solvents may serve in the place of their halogenated counterparts;
3. Aqueous solvents are increasingly replacing hydrocarbons as the reaction media of choice;
4. Alcohols can replace benzene;
5. Cyclohexane can replace carbon tetrachloride;
6. Sodium hypochlorite can replace sodium chromate.

Common Chemical Substitutions

<table>
<thead>
<tr>
<th>Original Material</th>
<th>Substitute</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetamide</td>
<td>Stearic acid</td>
<td>In phase change and freezing point depression</td>
</tr>
<tr>
<td>Benzene</td>
<td>Alcohol</td>
<td>Determination of molecular weight by freezing point depression</td>
</tr>
<tr>
<td>Benzoyl peroxide</td>
<td>Lauryl peroxide</td>
<td>When used as a polymer catalyst</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>Cyclohexane</td>
<td>In test for halide ions</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>Peracetic acid</td>
<td>In cleaning of kidney dialysis machines</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>Formalternate Flinn Scientific</td>
<td>For storage of biological specimens</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>Ethanol</td>
<td>For storage of biological specimens</td>
</tr>
<tr>
<td>Formalin</td>
<td>See Formaldehyde</td>
<td></td>
</tr>
<tr>
<td>Halogenated Solvents</td>
<td>Nonhalogenated Solvents</td>
<td>In parts washers or other solvent processes</td>
</tr>
<tr>
<td>Mercuric chloride reagent</td>
<td>Amitrole (Kepro Circuit Systems)</td>
<td>Circuit board etching</td>
</tr>
<tr>
<td>Sodium dichromate</td>
<td>Sodium hypochlorite</td>
<td></td>
</tr>
<tr>
<td>Sulfide ion</td>
<td>Hydroxide ion</td>
<td>In analysis of heavy metals</td>
</tr>
<tr>
<td>Toluene</td>
<td>Simple alcohols and ketones</td>
<td>Solvents</td>
</tr>
<tr>
<td>Wood's metal</td>
<td>Onions Fusible alloy</td>
<td></td>
</tr>
<tr>
<td>Xylene</td>
<td>Simple alcohols and ketones</td>
<td>Solvent</td>
</tr>
<tr>
<td>Xylene or toluene based liquid scintillation cocktails</td>
<td>Nonhazardous proprietary liquid scintillations cocktails</td>
<td>In radioactive tracer studies</td>
</tr>
<tr>
<td>Mercury salts</td>
<td>Mercury free catalysts (e.g.(\text{CuSO}_4 \text{ TiO}_2 \text{ K}_2 \text{ SO}_4 \text{ 3}))</td>
<td>Kjeldahl digests</td>
</tr>
</tbody>
</table>

5.6 MICROSCALE CHEMISTRY/PROCESS MODIFICATION
Microscale chemistry is an environmentally safe pollution prevention method of performing chemical processes using small quantities of chemicals without compromising the quality and standard of chemical applications in education. Microscale chemistry is performed by using: drastically reduced amounts of chemicals, safe and easy manipulative techniques, and miniature labware and high quality skills.

The benefits of microscale chemistry include: reduction in chemical use promoting source reduction, improved lab safety (better air quality, less exposure to chemicals, no fires, no spills, etc.), reduction in laboratory costs, shorter experiment times, and saves on storage space.

Examples:
1. measurement of physical properties
2. microscale distillation and reflux
3. microscale filtration and purification
4. microscale in analytical chemistry  
5. microscale synthesis and characterization  
6. microscale electrochemistry

Process modification is the scaling down the magnitude of the procedures and experiments offers enormous potential for WM. Fortunately, modern laboratory instrumentation requires smaller quantities of chemicals than were used in the past to achieve satisfactory analytical results. For teaching laboratories, instructors should plan experiments based on the smallest scale possible. Microscale procedures and equipment use smaller quantities of reagents, result in smaller quantities of waste, are safer, and teach careful laboratory techniques. Try to use the minimum amounts of hazardous chemicals when necessary.

Examples:
1. Use hazardous solvents and cleaners sparingly;
2. Choose physical test methods over wet chemistry;
3. Conduct instrument and physical analysis, which generates very little waste.

6. Other Management Techniques

6.1 EVAPORATION

Evaporating small quantities (100 ml. or less) of volatile materials is a viable method for managing hazardous wastes. Such a procedure must be executed within a working fume hood and should not involve materials that yield explosive or flammable residues. Some solvents suitable for evaporation are as follows:

<table>
<thead>
<tr>
<th>Acetone</th>
<th>1,2-Dichloroethylene</th>
<th>Methyl alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Butanol</td>
<td>Diethyl ether</td>
<td>Methyl ethyl ketone</td>
</tr>
<tr>
<td>Butyl alcohol</td>
<td>Ethyl acetate</td>
<td>Pentane</td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>Ethyl alcohol</td>
<td>Perchloroethylene</td>
</tr>
<tr>
<td>Chloroform</td>
<td>Heptane</td>
<td>2-Propanol</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>Hexane</td>
<td>Trichloroethylene</td>
</tr>
<tr>
<td>Dichloromethane</td>
<td>Isopropyl alcohol</td>
<td>Xylene</td>
</tr>
</tbody>
</table>

6.2 DRAIN DISPOSAL IN THE SANITARY SEWER SYSTEM

No user shall introduce directly or indirectly into the public works any pollutant or wastewater which will interfere with or adversely affect the operation or performance of the Publicly Owned Treatment Works (POTW), or pass through the POTW into the waters of the Commonwealth of Pennsylvania and causes, alone or in conjunction with other discharges, a violation of any requirement of the POTW’s NPDES permit, or adversely affect the use of disposal of the POTW’s sludge.
No user shall introduce any of the following substances in the POTW:

- **Ignitable waste.** A waste or substance which can create a fire hazard in the POTW which has any of but is not limited to the following properties:
  - It is a liquid with a flash point less than 60 degrees C (140 degrees F) using the test methods specified in 40 CFR 261.21
  - It is an oxidizer as defined in 49 CRF 173.151

- **Reactive/Explosive Waste.** A waste or substance which can create an explosion hazard in the POTW which has any of but is not limited to the following properties:
  - It is normally unstable and readily undergoes violent change without detonating.
  - It reacts violently with water.
  - It forms potentially explosive mixtures with water.
  - When mixed with water, it generates toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
  - It is a cyanide or sulfide bearing waste which can generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment.
  - It is capable of detonation or explosive reaction if it is subjected to a strong initiating source or if heated under confinement.
  - It is readily capable of detonation, explosive decomposition or reaction at standard temperature and pressure.
  - It is a forbidden explosive as defined in 49 CRF 173.51, or a Class A explosive as defined in 49 CFR 173.53 or a Class B explosive as defined in 49 CRF 173.88.

- **Corrosive Waste.** A waste or substance which has any of the following properties:
  - It is aqueous and has a pH less than or equal to 5 or greater than or equal to 10, as determined by a pH meter.
  - It is a liquid and corrodes steel (SAE 1020) at a rate greater than 6.35 mm (0.250 inch) per year at a test temperature of 55C (130F).

- **Hazardous Waste.** All wastes that are defined as hazardous under the regulations enacted pursuant to the Resource Conservations and Recovery Act (RCRA) as specified in 40 CFR 261 or under the regulations promulgated pursuant to the Pennsylvania Solid Waste Management Act as specified in 25 PA Code 261, except as provided for in these regulations.

- **Thermal Waste.** Any wastewater with a temperature greater than 60C (140F). Also, heat in the amounts which will inhibit biological activity in the POTW resulting in
interference, but in no case heat in such quantities that the temperature at the POTW treatment plant exceeds 27C (80F).

- **Radioactive Waste.** Any waste which exceeds the naturally occurring background levels for either alpha, beta, or gamma radiation and/or any wastewater containing any radioactive wastes or isotopes of such half-life or concentration not in compliance with applicable State or Federal regulation.

- **Solid or Viscous Substances.** Any solid or viscous substances capable of causing obstruction to the flow in sewers or other interference with the proper operation of the Authority’s facilities or facilities discharging into the Authority’s system.

- **Malodorous/Noxious Substances.** Any pollutants or noxious or malodorous liquids, gases, or solids which either singly or by interaction with other wastes:
  - Result in the presence of toxic gases, vapors, or fumes in a quantity that may cause acute worker health and safety problems; or
  - Are sufficient to create a public nuisance or hazard to life or are sufficient to prevent entry into the sewers for maintenance and repair.

- Any pollutant, including oxygen demanding pollutants (BOD, etc.) released in a discharge at a flow rate and/or pollutant concentration which will cause Interference with the POTW.

- Any substance which will cause the POTW’s effluent or any other product of the POTW such as residues, sludges, or scums, to be unsuitable for reclamation processes, including any substance which will cause the POTW to be in noncompliance with sludge use or disposal criteria, guidelines, or regulations developed under Section 405 of the Act, any criteria, guidelines, or regulations promulgated pursuant to the Solid Waste Disposal Act, the Clean Air Act, the Toxic Substances Control Act or State laws or regulations applicable to the treatment or disposal of such effluent or such product.

- Petroleum oil, nonbiodegradable cutting oil, or products of mineral oil in origin in amounts that will cause interference or pass through, notwithstanding the provisions of Section 2.4 of these regulations relating to oil and grease.

6.3 **TREATMENT**

If other methods of waste minimization are inappropriate for your particular situation, a final option may be chemical treatment of the hazardous waste generated during use. As part of the experiment, neutralization, precipitation, oxidation/reduction, and distillation are examples of treatment techniques that may be applied to reduce hazardous waste quantities.

**REMINDER:** All of the treatment procedures identified below necessitate the involvement of an individual experienced in such activities.
Neutralization involving acids and bases is the most common type of treatment. Adjustments in pH can be made to neutralize a highly acidic or highly alkaline solution. A final pH level of between 6 and 9 is desirable. If the solution contains no other hazardous component as defined by 40 CFR 261 (i.e. one which is toxic), the neutralized solution can be treated as normal waste and disposed of in a sanitary sewer drain.

Precipitation and oxidation/reduction reactions can remove hazardous components from waste. Disposing of these materials may then be accomplished through normal means. Precipitates from these reactions may need to be treated more effectively in a formal disposal mode.

Incorporating treatment procedures as a part of experimentation within teaching laboratories serves a dual purpose. It not only reduces the hazardous wastes being produced, but it also teaches students responsible waste management. Providing students with the knowledge and understanding of correct minimization techniques would seem only to benefit the future generations of scientists.

An alternative to specific destruction of hazardous wastes in teaching laboratories would be to include within another experiment the hazardous waste generated. This procedure would serve the purpose of limiting waste production as well as supplying the "raw" materials for additional experimentation.

All alternatives to waste handling methods require prior planning in order to be incorporated within teaching lab activities. The benefits of doing so would be directed to the University (minimizing risks, overall waste reduction, lowering management costs), the academic department (minimizing waste generation, limiting waste handling), and the students as well (learning proper waste management responsibility, realizing the University's commitment to the reduction of hazardous waste, safety –less accidents).

**Bench Scale Waste Treatment**

If other methods of waste minimization are inappropriate for your particular situation, a final option may be chemical treatment of the hazardous waste generated during use. Neutralization, precipitation, oxidation/reduction, and distillation are examples of treatment techniques that may be applied to reduce hazardous waste quantities. Laboratories generating hazardous waste have a few options for treating hazardous waste on site without a permit. The small-scale treatment and deactivation of products and by-products as part of the experiment plan is one approach that can be used. Before undertaking any procedures, safety must always be the first consideration. All procedures should be carried out under the direct supervision of a trained scientist. During any procedure, personal protective equipment must be worn.
Treating hazardous waste on site in ways other than those provided for in the regulatory exclusions subjects generators to extremely high fines (e.g. up to $50,000 per day) and possibly incarceration.
7. Resources

Chemical Waste Management – in higher education
www.2fpm.wisc.edu/chemwasteinfo/

Lab Waste at Educational Institutes
http://www.epa.gov/epaoswer/osw/specials/labwaste/index.html

Developing a P2 Plan
http://outreach.missouri.edu/polsol/p2prog.htm

Environmental Virtual Campus
http://www.c2e2.org/evc/home.html

Labs Achieving Better Stewardship
http://www.labscentral.info/p2wm.asp

Waste Management Publications

Hazardous Waste Management
http://www.des.umd.edu/compliance/factsheet/hazwaste.html
70+ Ways to Reduce Hazardous Waste in the Laboratory

1. Write and follow a WM Plan
2. Include WM as part of student and employee training
3. Use manuals as part of your training – American Chemical Society’s “ACS Less is Better” or “ACS Waste Management Manual for Laboratory Personnel”
4. Create an incentive program for WM
5. Centralize purchasing of chemicals through one person in the department, or laboratory
6. Inventory chemicals, at least once a year
7. Indicate where the chemicals are located in the inventory
8. Update inventory when chemicals are purchased or used
9. Purchase chemicals in smallest quantities needed
10. If trying out a new procedure try to obtain the chemicals needed from another laboratory or purchase small amounts initially -after you know you will be using more of these chemicals purchase in larger quantities unless you can obtain excess chemicals from someone else
11. Date chemical containers when received, so that older ones will be used first
12. Audit your laboratory for waste generated, quantity, type, source, and frequency
13. Keep MSDSs for chemicals used
14. Keep information about disposal procedures for chemical waste
15. If possible, establish a central storage for chemicals
16. Keep chemicals in your storage area except when in use
17. Establish an area for storing chemical waste
18. Minimize the amount of waste kept in storage by utilizing waste collection days
19. Keep all waste containers in secondary containment
20. Label all chemical containers as to their contents
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 nitric acid wastes separate from other inorganic acid wastes
25. Keep non-hazardous chemical wastes separate from hazardous wastes
26. Keep highly toxic wastes (cyanides) separate from previous groups of wastes
27. Avoid experiments that produce wastes that contain combinations of radioactive, biological, and/or hazardous waste
28. Keep chemical wastes separate from normal trash, paper, wood, etc
29. Develop procedures to prevent and/or contain chemical spills; purchase spill clean up kits; contain areas where spill are likely to occur
30. 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
31. Eliminate the use of chromic acid cleaning solutions altogether
32. Eliminate the use of uranium and thorium compounds
33. Substitute red liquid spirit filled digital or thermocouple thermometers for mercury containing thermometers where possible
34. Use a bimetal or stainless steel thermometer instead of mercury thermometer in heating and cooling units
35. Evaluate laboratory procedures to see if less hazardous or non-hazardous reagents could be used
36. Review the use of highly toxic, reactive, carcinogenic, or mutagenic materials to determine if safety alternatives are feasible
37. Avoid the use of reagents containing arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.
38. Consider the quantity and type of waste produced when purchasing new equipment.
39. Purchase equipment that enables the use of procedures that produce less waste.
40. Review your procedures regularly (i.e., annually) to see if quantities of chemicals and or chemical waste could be reduced.
41. Look into the possibility of including detoxification and/or neutralization steps in laboratory experiments.
42. When preparing a new protocol, consider the kinds and amounts of waste products and determine whether they can be reduced or eliminated.
43. When researching a new or alternative procedure, include consideration of the amount of waste produced as a factor.
44. Examine your waste excess chemicals to determine if there are other uses in your laboratory; neighboring laboratories, department, or non-laboratory areas (garages, paint shops, or art department) might be able to use them.
45. When solvent is used for cleaning purposes, use contaminated solvent for initial cleaning and fresh solvent for final cleaning.
46. Try using detergent and hot water for cleaning of parts instead of using solvents.
47. Consider using ozone treatment for cleaning of parts.
48. Consider purchasing a vapor degreaser, vacuum bake, or a bead blaster for cleaning parts.
49. Use the smallest container possible for dripping or holding photographic chemicals.
50. Store and reuse developer in photo labs.
51. Precipitate silver out of photographic solutions for reclamation.
52. Neutralize corrosive wastes that don’t contain metals at the laboratory bench.
53. Deactivate highly reactive chemicals in the hood.
54. Evaluate the possibility of redistillation of waste solvents in your laboratory.
55. Evaluate other wastes for reclamation in your laboratory.
56. Scale down experiments producing hazardous waste whenever possible.
57. In teaching laboratories, consider the use of microscale experiments.
58. In teaching laboratories, use demonstrations or video presentations as a substitute for some student experiments that generate chemical waste.
59. Use pre-weighed or pre-measured reagent packets for introductory teaching laboratories where waste generation is high.
60. Include waste management as part of the pre and post laboratory written student experience.
61. Encourage orderly and tidy behavior in the laboratory.
62. Polymerize epoxy waste to a safe solid.
63. Consider using solid phase extractions for organics.
64. Put your hexane through the rotavap for reuse.
65. Destroy ethidium bromide using household bleach.
66. Run mini gels instead of full size slabs.
67. Treat sulfur and phosphorus wastes with bleach before disposal.
68. Treat organolithium waste with water or ethanol
69. Collect metallic mercury for reclamation
70. Investigate possibility for recovering mercury from mercury containing solutions
71. Recover silver from silver chloride residue waste, and gold from gold solutions
72. When testing experimental products for private companies, limit donations to the amount needed for research
73. Return excess pesticides to the distributor
74. Be wary of chemical donations from outside the University; accept chemicals only if you will use them within 12 months
75. Replace or dispose of items containing polychlorinated biphenyls
Sec. 262.27 Waste minimization certification.

A generator who initiates a shipment of hazardous waste must certify to one of the following statements in Item 15 of the uniform hazardous waste manifest:

(a) ``I am a large quantity generator. I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment;'' or

(b) ``I am a small quantity generator. I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.''

[70 FR 10817, Mar. 4, 2005]

Effective Date Note: At 70 FR 10817, Mar. 4, 2005, subpart B was amended by adding new Sec. 262.27, effective Sept. 6, 2005.
MEMORANDUM

SUBJECT: Hazardous Waste Generated in Laboratories

FROM: Elizabeth Cotworth, Director Office of Solid Waste

TO: RCRA Senior Policy Advisors, EPA Regions I-X

The purpose of this memo is to reiterate and clarify the Environmental Protection Agency’s (EPA) policies under the Resource Conservation and Recovery Act (RCRA) hazardous waste management program regarding: 1) who may make a hazardous waste identification, and 2) the regulatory status of on-site treatment of hazardous waste. This memo is aimed primarily toward academic institutions that generate hazardous waste in laboratories.

Background Academic institutions across the country vary in size and complexity. Many are large quantity generators (LQGs) of hazardous waste, generating >1000 kg/month; or >1 kg of acute hazardous waste/month. LQGs must comply with the regulations in 40 CFR 262.34(a) for the accumulation of waste on-site. Hazardous wastes produced by LQGs may be accumulated on-site without interim status or a permit for 90 days or less. Many other academic institutions are small quantity generators (SQGs), generating >100 kg/month but <1000 kg/month of hazardous waste. SQGs must comply with 40 CFR 262.34(d) for accumulation of waste on-site. Hazardous wastes produced by SQGs may be accumulated on-site without interim status or a permit for 180 days or less.

Many of the hazardous wastes managed at academic institutions are produced and initially accumulated in research laboratories. The satellite accumulation provisions of 40 CFR 262.34(c) allow for reduced requirements for hazardous waste accumulated in containers at or near any point of generation. Both LQGs and SQGs may take advantage of the reduced requirements while hazardous waste is in satellite accumulation areas, such as laboratories, provided the waste is managed in accordance with the provisions of 40 CFR 262.34(c) (e.g., properly labeled).

Who may determine whether a waste is hazardous? 40 CFR Section 262.11 states, “A person who generates a solid waste...must determine if that waste is a hazardous waste...” A “person” is defined as “an individual, trust, firm, joint stock company, Federal Agency, corporation (including a government corporation), partnership, association, State, municipality, commission, political subdivision of a State, or any interstate body” (40 CFR Part 262.10). A “person” is not limited to a specific individual. Therefore, any individual who is part of the “person” (as defined) may make a hazardous waste determination. The hazardous waste determination is not limited to the individual who actually produces a solid waste. For example, Environmental, Health & Safety (EH&S)
personnel may make a hazardous waste determination for a waste produced by an individual researcher, as long as the EH&S personnel and the researcher are part of the same "person" (e.g., academic institution).

Of course, EPA's objective is to ensure accurate hazardous waste identification. Proper waste identification is important in order to allow the generator to comply with applicable requirements such as those for labeling and marking pursuant to 40 CFR 262.34. In short, it is the "person's" responsibility to ensure that the individuals within the organization who are making the hazardous waste determination obtain all the necessary information from whichever individuals within the organization have that information. In practice, a hazardous waste determination in a laboratory setting would ideally be a collaborative effort between the individual researcher who produces the waste and EH&S personnel who may make the hazardous waste determination. That is, EH&S personnel making a hazardous waste determination should receive sufficiently accurate and detailed information about each waste from the individual researcher to ensure accurate waste identification.

We realize that having addressed the question of who may make a hazardous waste determination may also raise the question of where a hazardous waste determination is made. The issue is whether a hazardous waste determination must be made in the laboratory (typically a satellite accumulation area) or at a central accumulation area. EPA is not addressing this question in this memo, but intends to address this question in a future guidance or rulemaking.

**What is the regulatory status of on-site treatment of hazardous waste?** EPA has consistently interpreted its regulations to allow generators to treat hazardous waste in their accumulation tanks and containers, without obtaining a permit or having interim status. This is true for both LQGs and SQGs. Of course, all generators are allowed to treat only the hazardous waste that is generated on-site. A permit would be required to store and/or treat hazardous waste that is consolidated from off-site locations. Examples of treatment that may be conducted in accumulation tanks and containers include precipitating heavy metals from solutions, and oxidation/reduction reactions.

There are three reasons for this interpretation. First, we discussed the relationship between storage, treatment and disposal in the preamble of the January 12, 1981, Federal Register (46 FR 2806-2808). In that preamble, we noted that treatment can occur at a permitted disposal or storage facility without affecting that facility's regulatory status. We believe that treatment activities should similarly not change the regulatory status of generators. Since the regulations do not impose additional standards for treatment when it occurs at a storage facility that requires a permit, there is no basis for regulating treatment more strictly at a storage facility which does not require a permit, such as a generator's accumulation area.

Second, the provisions of 40 CFR 262.34(a) for LQGs and 40 CFR 262.34(d) for SQGs require generators to comply with most of the technical standards for containers (Part 265

http://yosemites.epa.gov/osw/rcra.nsf/Documents/B0C8C9E419CC8DB485256C6E005949B6 6/12/2003
Subpart I) and tanks (Part 265 Subpart J) with which an interim status storage facility would have to comply. Of the provisions for treatment, storage and disposal facilities only the financial responsibility, closure/post-closure and corrective action regulations would not apply to generators that treat hazardous waste.

Third, treatment often renders waste less hazardous, or more amenable for further treatment, recycling, shipment off site, etc. A requirement for generators to obtain a permit for any on-site treatment would very likely discourage such practices.

Finally, with regard to who may treat a hazardous waste, a generator is defined as “any person, by site, whose act or process produces hazardous waste...” (40 CFR 2601.10). Therefore, again, any individual who is part of the “person,” as defined, including EH&S personnel, is allowed to conduct treatment, provided that the individual complies with the training requirements of 40 CFR 262.34(a)(4) for LQGs, or 40 CFR 262.34(d)(5) for SQGs. Additionally, nothing in 40 CFR 262.34 precludes generators from transferring waste between tanks or containers to facilitate storage or treatment.

It should be noted, however, that some forms of treatment by generators are not allowed without a permit. For example, incineration is regulated by specific standards for incinerators (Part 264/265 Subpart O), and burning waste in boilers and industrial furnaces is regulated under the specific standards for those units (Part 266 Subpart H).

If the waste is being treated on-site and the treatment residue is destined to be land disposed, the generator still has responsibilities under the land disposal restrictions (LDR) program. The LDRs require that hazardous waste must be treated by a specified method or to a specified constituent concentration level before it (or its residue) may be placed in the land. The generator must know the treatment standard applicable to his/her waste and either treat to meet the treatment standard or send it to a treater to do so. Generators who treat waste on-site to remove a hazardous characteristic must prepare a waste analysis plan if treatment occurs in units that do not require a RCRA permit (see 40 CFR 262.34 (a)(4) for LQGs, and 40 CFR 262.34(d)(4) for SQGs). In addition, there are some generator paperwork requirements associated with the LDRs (40 CFR 268.7(a)). More information about the LDR program may be found in “Land Disposal Restrictions: Summary of Requirements” at http://www.epa.gov/epaoswer/hazwaste/ldr/new.htm.

Some treatment units have been and continue to be specifically excluded from permitting. For example, owners and operators of elementary neutralization units are not required to obtain a RCRA permit (40 CFR 270.1(c)(2)(v)). Similarly, many forms of on-site recycling of hazardous waste can be performed without a permit, since EPA generally does not regulate the recycling process itself. However, any accumulation of hazardous waste prior to placement in an exempt unit or prior to recycling would be regulated under 40 CFR 262.34, as discussed above.

On a related matter, for those LQGs that accumulate hazardous waste for longer than 90 days, or SQGs that accumulate hazardous waste for longer than 180 days, and therefore require a permit, the Agency recently proposed a rule that would streamline the
permitting requirements for facilities that store and/or treat their hazardous waste on-site in tanks and containers (October 12, 2001; 66 FR 52192). The Agency anticipates finalizing the rule in early 2003.

Please note that this letter discusses only the federal hazardous waste regulations. States that are authorized to implement the RCRA program may have regulations that are different than the federal regulations provided they are not less stringent than the federal program. If you have any questions, please contact Kristin Fitzgerald at (703) 308-8286 or fitzgerald.kristin@epa.gov