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Project in Excellence and Leadership: New England Universities' Laboratories Mid-Term Evaluation: Piloting Superior Environmental Performance in Labs

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Executive Summary

In 1999, a consortium of university laboratories in New England joined the U.S. Environmental Protection Agency's (EPA) Project XL (eXcellence and Leadership) program to test an innovative idea to reduce regulatory inefficiencies and achieve better environmental performance in laboratories than what is required under the current regulatory structure. This pilot initiated a new system of collaboration and partnership between the three New England Universities, EPA, the Massachusetts Department of Environmental Protection, and the Vermont Department of Environmental Conservation. The New England Universities' Laboratories (NEU Labs) project grew from the perception that current regulatory requirements that pertain to laboratories under the Resources Conservation and Recovery Act (RCRA) and Occupational Safety and Health Administration (OSHA) programs are duplicative and inefficient. Whereas the OSHA laboratory standard is written specifically for laboratories, RCRA Subtitle C requirements make no distinction among its many different regulated entities. This dual and dissimilar regulatory scheme currently governing laboratories has proven to be unwieldy.

Under Project XL, the three universities proposed an innovative environmental management system for laboratory wastes and promoted superior environmental management and performance in laboratories. Their approach was to harmonize the OSHA and RCRA requirements in a system that requires the use of performance-based criteria to effectively manage laboratory wastes under one holistic guiding document, an Environmental Management Plan (EMP), that is specifically tailored to the research needs and processes of each university. The new system focused on the following priority areas: (1) increasing faculty, laboratory staff, and student training in order to improve individual behavior in the laboratory and overall environmental awareness of staff and students; (2) generating pollution prevention ideas; (3) reducing laboratory hazardous waste generation; and (4) increasing chemical redistribution and reuse. By December 2000, all three schools had implemented their EMPs and had actively begun to track their commitments and progress in meeting the stated goals and objectives of the pilot project.

In June 2001, the three schools issued the first annual progress report for the project. It was clear in the first progress report that a heavy investment of time and resources on the part of Environmental, Health and Safety (EHS) staff at each institution had borne much fruit. At the same time, there was some frustration at the lack of movement in distinct areas of the EMP that would lead to improved environmental performance, and that it was difficult to paint a clear picture why the schools were seeing certain EMP elements take hold and why others seemed to be having minimal impacts. Based on these experiences, the three institutions, EPA and the States initiated a mid-term evaluation of the project in September 2001. This was the official midpoint of the project. The Final Project Agreement between EPA, the States and schools is set to expire in September 2003 unless the project is extended.

The goal of the mid-term evaluation is to garner lessons learned from the unique approach to laboratory management being tested by the three institutions and to highlight opportunities to improve the overall environmental performance for the universities for the remainder of the project. The evaluation emphasizes the results of the universities' efforts to actively encourage chemical reuse and recycling, enhance conformance with internal policies, increase efficiency, and promote environmental stewardship within laboratories. The evaluation measures progress based on nine Environmental Performance Indicators (EPIs) relative to baseline performance in five areas. The baseline measures cover the following areas: hazardous chemicals of concern surveys, measurement of laboratory wastes over six months, environmental awareness surveys, evaluation of laboratory wastes reused or redistributed, and the measurement of costs of compliance including waste disposal costs. Much of the data collected and reported is generated from annual reporting activities by the universities. However, a substantial portion of the data collected is qualitative in order to gain an understanding of why and how certain aspects of the project are working and why certain long-term environmental objectives may face realistic hurdles in the laboratory setting. Group discussions were conducted at each school in March 2002. The groups were comprised of EHS staff, faculty, principal investigators, laboratory staff and students.

The first eight sections of the report together represent the basic workings of pilot implementation in each of the schools. Although this background information is not the crux of the evaluation it serves to enhance the reader's understanding of the results of the evaluation and would allow for the replication of this pilot, if applicable to other colleges and universities. The performance data based on the EPIs are presented in Section 9. For most EPIs, the baseline results are assessed, followed by data collected in 2000-2001 and the most current data present for 2001-2002. The level of information discussed is dependent on the EPI, the university, and the way in which data was obtained. Findings and recommendations for all three universities are listed for each specific EPI. Section 10 presents lessons learned overall from the pilot experience and the concluding recommendations for all of the project partners.

Based on this mid-term assessment of this project, one can say that this project has shown great success in some important areas: developing EMPs, training staff, increasing awareness, shifting attitudes and behaviors, improving the range of activities that determine compliance and emergency preparedness, and demonstrating that the environmental management system approach to managing laboratory waste is slowly gaining hold and making progress. At the same time, the project has not shown the expected successes in other areas such as chemical reuse and redistribution or pollution prevention. Therefore, the results of this mid-term evaluation should not be interpreted to be a summative evaluation on the merits of regulatory change for laboratories. This project is an innovative approach to laboratory management not only for the universities but also for the Federal and State regulators involved. This is one of a few pilot approaches being tested throughout the country and will eventually feed information into potential future regulatory innovation. The utility of this mid-term evaluation is in identifying the strengths and weaknesses of the project, offering suggestions for continuous improvement, and creating a system of learning within EPA, the States, and the universities on laboratory innovation. The intended users of the evaluation are not only the three universities involved, but also the larger universe of academic institutions all grappling with similar environmental management and regulatory issues.

The key to understanding why certain EMP elements are implemented with relative ease and why others have fallen short of expectations lies in understanding academic culture. The primary lesson learned is that EHS, EPA, and the States need to work within the challenges of an academic culture, but also capitalize on the benefits of an academic culture. For example, EHS staff at all three universities invested a lot of energy and time into trying to meet two EPI goals in particular that dealt with increasing chemical redistribution and reuse, and decreasing waste generation. Based on the group discussions, it is evident that it is extremely challenging to achieve the stated goals for these EPIs as the culture of research, with its demands for chemical purity and scientifically acceptable protocols, stifle researchers' motivation to reduce chemical inputs, increase chemical reuse, and reduce waste.

[redacted]

Group discussion data at each school supplemented performance data in the areas of training, compliance, and behavior changes. Staff and student training are raising the level of awareness and are slowly starting to change the behaviors of individuals. This awareness and training are vital to the long-term success of the project as compliance, or lack thereof, can be dependent on the actions of one individual. These findings and others discussed in the report do point to some changes for the universities over the life of the project. For example, the evaluation suggests that EHS should re-prioritize its emphasis on certain EPI elements—for the remaining year (or years following if the project is extended), it is best to focus on making strides in pollution prevention. In fact, the participants in the project are sponsoring a pollution prevention workshop scheduled for November 2002. The following are the overarching lessons learned and recommendations:

- **Work within the challenges of an academic culture—capitalize on the benefits of an academic culture**
  Challenges:
  - High level research requires chemical purity
  - Scientifically acceptable research protocols limit chemical reductions
  - Tracking laboratory progress and staff training is difficult
  - Intransigent faculty and researchers can impede implementation of an innovative program
  - Responsibility and accountability are not straightforward in a laboratory setting
  - Compliance can suffer without proper leadership
  - One individual makes all the difference

  Benefits:
  - Compliance happens when regulations "make sense," are unambiguous and straightforward
  - Energized students can be the catalysts for change
  - Mission and purpose are vital to the success of an innovative program
  - Collaboration fosters a problem-solving environment
  - Department champions in many cases will have better compliance in their laboratories
  - One individual makes all the difference

- **Prioritize EMP elements to improve environmental performance over the next two years by focusing on pollution prevention**—The other EPIs, while worthy goals and should not be forsaken, are so dependent on research grants and research that any progress made in one semester can be easily erased in the next. Achieving pollution prevention in laboratories is more lasting, attainable, and most transferable to other laboratories and schools.

[redacted]

- **Improve EMP compliance**—It is impressive that in almost all laboratories involved in this project, staff and students were familiar with EHS staff and had received laboratory training. However, the schools are still having difficulty complying with some of the Minimum Performance Criteria—the EMP elements that most closely mimic the RCRA regulation they were meant to improve upon.

- **Create a system of accountability. EHS staff at all three schools need a better suite of tools—both incentives and self-policing—to create a partnership with laboratory staff, faculty and students to improve laboratory management**—EHS staff need both "carrots and sticks" in order to change behaviors. School administrators need to support EHS staff in their efforts, and EHS needs to look into more ways to expand their reach in the laboratory to work with individuals.

- **Performance measurement goals may not always be the right measures and can overly narrow the focus of the project and overwhelm project implementation**—The EPIs were designed to measure success in terms of superior environmental performance and to test a better regulatory scheme in return for superior environmental performance. The schools, EPA, and the States are still investigating appropriate ways to measure whether these goals have been achieved.

- **Top college and university Administration support is crucial and it has to be reinforced periodically**—There are many day-to-day and month-to-month activities associated with environmental, health and safety management, but as in any endeavor, continuous improvement only occurs if the feedback loop is complete and operating smoothly.

[redacted]

- **There are benefits to coupling health and safety requirements with environmental regulation—**A recurring theme from the group discussions is that simplifying requirements—especially those that overlap—and having one consistent training session on health and safety and environmental management has greatly improved staff and students ability to understand what is required of them.

- **Benchmarks and baseline information are necessary to be able to measure progress**—Progress for this project would be better measured if baseline audits for all relevant EPIs took place prior to EMP implementation and if baseline data was robust and quality.

- **Reporting consistency is critical to improving data quality and measuring progress**—The schools need to stress data consistency in their reporting over time. The schools can simplify their reporting by using one information template and by detailing which initiatives remain in progress, new projects started, or efforts retired. Without consistent reporting, it is difficult to explain results and measure progress.

- **Focus on the long-term benefits of training. Answer the questions of "why" in addition to focusing on the "how"**—While it is still of utmost importance to stress how laboratories should be properly managed, it is clear from the group discussions that time spent on addressing why it is important to properly store and dispose of waste and how waste disposal impacts the environment, could result in behavioral changes.

- **Create more opportunities for EMP users to be instruments of change in the laboratories**—The simple act of gathering people who believe in and understand the EMP can generate new ideas and excitement about expanding the options available in laboratories to create positive environmental results.

[redacted]

- **Long-term attitudinal and behavioral change is possible with training and extensive communication**—Training and constant feedback to and from the EHS departments identifying what is working, what remains unclear, where people are succeeding, and the support of school Administrators are the real ways in which behavioral shifts can occur in an academic setting.

- **Utilize institutional champions**—The schools need to make use of those individuals and Administrators who are supportive of this project and recognize the value of having this project succeed in order to make inroads on the challenges ahead.

[redacted]

It is difficult to neatly package the findings of this evaluation and declare success or disappointment for the whole project based on two years of implementation. The lessons learned highlight areas of great progress and areas that require further thought, discussion, brainstorming, and action. However, the lessons learned do not adequately emphasize all of the hard work that has been invested into this project by the schools, the States and EPA. In the era of heightened awareness of domestic security issues, colleges and universities can benefit from a more holistic management scheme, such as the NEU Labs project, that stresses chemical awareness, proper chemical handling, disposal, and better laboratory housekeeping in general. One thing is clear—the lessons learned from this evaluation will be invaluable if implemented and used to affect change in the universities.

Looking forward, EPA, the States and the schools should continue to work together to strengthen this innovative partnership and to continue to seek out solutions to the difficult challenges that remain in laboratories and to explore new options for improving environmental, health and safety on college and university campuses. As the universities, States and EPA systematize their abilities to creatively solve problems there are greater opportunities to seek environmental gains in areas not solely focused on laboratories. These opportunities hold great promise for these schools that can be called innovators. Energy efficiency in laboratories, enhanced and holistic chemical management programs, and exploring multi-media environmental management systems on college and university campuses can offer new superior environmental performance horizons for the project partners to tackle.

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The three universities, EPA New England, the Massachusetts Department of Environmental Protection, and particularly the dedication of Steve Simoes at the Vermont Department of Environmental Conservation should be applauded in their efforts –especially considering the challenges –to partner, experiment, learn and innovate in order to promote superior environmental performance in college and university laboratories.

The Project Manager for this evaluation was Suganthi Simon, of EPA's Office of Policy, Economics and Innovation. Consultant support was provided under Contract 68-WA-98-207 between EPA and Industrial Economics, Inc. Robert Black and Scott Cole of Industrial Economics, Inc., assisted in conducting group discussions, compiling and analyzing data on environmental awareness surveys, and reviewing university compliance information.

Section 1 Introduction and Background

1.1 Introduction
This mid-term evaluation of the New England Universities' Laboratories (NEU Labs) Project in Excellence and Leadership (Project XL) is focused on the progress and lessons learned from two years of implementation of Project XL conducted by three universities in New England. The schools piloted an Environmental Management Standard for University Laboratories finalized in the *Federal Register* (Volume 64, Number 187, page 52380) dated September 28, 1999.

The utility of this mid-term evaluation is in identifying the strengths and weaknesses of the NEU Labs program, offering suggestions for continuous improvement, and creating a system of learning within EPA, the States, and the universities on laboratory innovation. The intended users of this evaluation are not only the three XL universities, but also the larger universe of academic institutions all grappling with similar environmental management and regulatory issues. It is for this larger audience that the evaluation provides more background information on project development and structure so that pieces of this Labs XL experiment, if applicable, may be replicated in other institutions. In addition, the U.S. Environmental Protection Agency (EPA) is an intended audience for this report, as it will help to inform a national dialogue on the potential for regulatory reform for academic laboratories.

1.2 Background
Colleges and universities, like their counterparts in industry, are required to comply with many applicable environmental requirements to protect human health and the environment. Most academic institutions are similar to small cities and encompass many analogous activities within their campus borders such as operating research laboratories, auto repair facilities, power plants and wastewater treatment plants; disposing of hazardous waste and trash; managing asbestos; supplying food, shelter, and drinking water to their population; maintaining grounds; and even, in some instances, incinerating wastes. Many universities also operate medical and research facilities that create their own set of environmental challenges. There are an estimated 150,000 private and public research laboratories in the United States, including university and academic laboratories. Laboratories are a unique setting in which most researchers operate independently, but collaboratively with peers both locally and on a worldwide basis. In general, these researchers are responsible for the daily control of operations, in partnership with the institutional administration. Each laboratory may have potential impacts on the natural environment and workers' health and safety. The major environmental and health and safety aspects associated with laboratories are hazardous waste management, chemical management, and energy usage[1]. The major regulatory concerns are focused on hazardous waste and laboratory chemical management as they pose a greater immediate risk to the environment and public health. Universities and colleges agree that hazardous wastes generated by laboratories should be regulated however, the problem is that the regulations were designed for waste management firms and industrial settings and therefore are neither well harmonized to fit the scope of the laboratory waste streams nor the activities of the laboratories. The magnitude of the overall laboratory waste problem also remains unclear. Colleges and universities are estimated to generate only about 1/100 of 1 percent of the nation's hazardous waste.[2]

The Occupational Safety and Health Administration (OSHA) and the EPA have jurisdiction over two major regulations that affect hazardous waste and chemical management in laboratory operations. The two laws that have the most impact on the environmental performance of university laboratories are the EPA Resource Conservation and Recovery Act (RCRA) Subtitle C program and the OSHA Occupational Exposure to Hazardous Chemicals in Laboratories regulation (the OSHA Laboratory Standard). These regulations are implemented differently as explored below, however the major implication of this dual regulation system is that laboratory management is required to implement and track two parallel and not always consistent chemical management systems within the laboratory setting. RCRA includes externally imposed

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1 The energy inefficiencies of laboratories are not currently regulated. According to EPA estimates, the typical laboratory uses five times as much energy and water per-square-foot as the typical office building due to intensive ventilation requirements and other health and safety concerns.
2 *Recommendations of the Laboratory Regulatory Reform Task Force: Report to California Environmental Protection Agency, Department of Toxic Substances Control.* (1995)

requirements governing the management and handling of "hazardous waste" while OSHA is built on a performance-based, internally-developed management system governing the management and handling of "hazardous chemicals". These two regulatory programs often appear to create a confusing system in the laboratory and for researchers, and can result in regulatory non-compliance in laboratory settings.

Section 2 RCRA and OSHA Regulations for Laboratories

2.1 RCRA Background for the NEU Labs Project

The Resource Conservation and Recovery Act (RCRA), an amendment to the Solid Waste Disposal Act, was enacted in 1976 to manage the nation's hazardous and municipal solid waste through "cradle-to-grave" regulations. The RCRA regulatory program has four main goals: (1) to protect human health and the environment from the hazards posed by waste disposal; (2) to conserve energy and natural resources through waste recycling and recovery; (3) to reduce or eliminate, as expeditiously as possible, the amount of waste generated, including hazardous waste; and (4) to ensure that wastes are managed in a manner that is protective of human health and the environment.

The RCRA program is sub-divided into three interrelated programs of which Subtitle C, is the regulatory program covering hazardous solid waste. RCRA Subtitle C establishes a federal program to manage hazardous wastes from cradle-to-grave—the generation, transportation, treatment, storage, or disposal of hazardous wastes. The Subtitle C program has resulted in perhaps the most comprehensive regulation EPA has ever developed. The regulated community that must understand and comply with RCRA and its regulations is a large, diverse group. It includes not only facilities typically thought of as hazardous waste generators, such as industrial manufacturers, but also government agencies and small businesses, such as a local dry cleaner generating small amounts of hazardous solvents, or a gas station with underground petroleum tanks[3]. Under RCRA, a hazardous waste is defined as a "solid waste or combination of solid wastes, which because of its quantity, concentration, or chemical, or infectious characteristics may (1) cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness or (2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed."

In its 26-year history, the RCRA program has increasingly heard from the regulatory community—especially those subject to Subtitle C—that some RCRA regulations cannot be implemented efficiently or effectively to achieve the intended results across such a wide range of constituent industries and businesses. The academic and research community has been particularly attuned to the difficulty of employing RCRA hazardous waste regulations that were largely intended for industrial operations. The RCRA Subtitle C regulations are most efficient when targeted at larger volumes of a small number of hazardous wastes that are consistently produced. In contrast, university laboratories typically generate relatively small quantities of many different hazardous wastes on a discontinuous basis[4].

An important section of RCRA (RCRA, Section 3006) encourages EPA to authorize a qualified state to administer and enforce a hazardous waste program in the state in lieu of the federal program. State authorized programs may impose requirements that are more stringent or broader in scope that the federal RCRA program. As a result, variation exists in how certain RCRA requirements apply to academic research institutions. Within this authority, both regional EPA offices and states have reached varying interpretations of specific RCRA issues as applied to laboratory waste management.

2.2 The OSHA Laboratory Standard

The OSHA Laboratory Standard, promulgated in 1990, formally recognized several unique aspects of laboratories and laboratory operations and established a performance-based system for regulating them. The Occupational Safety and Health Agency enacted the Lab Standard ("Occupational Exposure to Hazardous Chemicals in Laboratories Standard, 29 CFR 1910.1450), which states:

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[3] *RCRA Orientation Manual* (EPA Publication, May 1998).
[4] *New England Universities' Laboratories ProjectXL Final Project Agreement* (September 1999).

"The Laboratory Standard….is designed to provide a comprehensive approach for the protection of laboratory workers which is more appropriate to laboratory conditions than compliance with the substance specific standards in 29 CFR part 1910, subpart Z. The Laboratory Standard requires that employers protect workers through the development and implementation of work practices and control measures expressly tailored to the individual laboratory workplace."

Such a performance-based system is often more effective, both for the laboratories being regulated and for those regulatory agencies concerned with health, safety, and the environment[5]. The OSHA Laboratory Standard is centered on a *Chemical Hygiene Plan* (CHP). The CHP is a written plan by each university or research institution that must include the following points:

- Employee information and training about the hazards of chemicals in the work area, including how to detect their presence or release, work practices and how to use protective equipment, and emergency response procedures;
- The circumstances under which a particular laboratory operation requires prior approval from the employer;
- Standard operating procedures for work with hazardous chemicals;
- Criteria for use of control measures, such as engineering controls or personal protection equipment;
- Provisions for additional employee protection for work with "select carcinogens" and for reproductive toxins or substances that have a high degree of acute toxicity;
- Provisions for medical consultations and examinations for employees; and
- Designation of a chemical hygiene officer.

Although the CHP requires the aforementioned generic conditions, each CHP is modified to specific laboratory functions and its workers allowing for flexibility in its implementation.

Section 3 New England Universities' Laboratories Project XL

3.1 Project XL Background

In 1995, EPA embarked on an innovative program to test ideas that demonstrate eXcellence and Leadership (Project XL) by those who must comply with Agency regulations and policies. Project XL solicits ideas from private and public sector facilities, states, trade associations, and communities that propose solutions to difficult technical and regulatory problems and explore new approaches to protecting human health and the environment. By opening the door to experimentation, Project XL invites creativity and promotes new ways of achieving superior environmental performance while usually lowering the cost or lessening the regulatory burden of the project sponsor.

The program offers regulatory, program, policy, or procedural flexibilities to conduct the experiment. Under Project XL, project sponsors commit to conduct experiments that address the eight Project XL criteria:

1. produce superior environmental results beyond those that would have been achieved under current and reasonably anticipated future regulations or policies;
2. produce benefits such as cost savings, paperwork reduction, regulatory flexibility or other types of flexibility that serve as an incentive to both project sponsors and regulators;
3. have the support of stakeholders;
4. achieve innovation/pollution prevention;
5. produce lessons or data that are transferable to other facilities;
6. demonstrate feasibility;
7. establish accountability through agreed upon methods of monitoring, reporting, and evaluations; and
8. avoid shifting the risk burden, i.e., do not create worker safety or environmental justice problems as a result of the experiment.

[5] *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals.* National Academy of Sciences (1995).

Interested in promoting environmental regulations that reflect the unique situation of laboratories and reducing the amount of chemical waste produced, a group of universities from across New England formed the Laboratory Consortium for Environmental Excellence (LCEE) in 1997. Later renamed the Campus Consortium for Environmental Excellence (C^2E^2)[6], the Consortium is a not-for-profit corporation whose member colleges, universities, and research organizations are interested in promoting the continual improvement of environmental management programs and systems at academic institutions and research organizations, including the management and disposal of hazardous chemicals from campus laboratories. In 1997, three schools in New England—Boston College (Chestnut Hill, Massachusetts), the University of Massachusetts Boston (Boston, Massachusetts), and the University of Vermont (Burlington, Vermont)—began discussions to submit a proposal to the Project XL program. With the help of C^2E^2, the schools submitted a proposal to EPA in 1998. A Final Project Agreement (FPA) to govern the implementation of the project was signed between the schools, EPA New England and EPA Headquarters, the Vermont Department of Environmental Conservation (VT DEC), and the Massachusetts Department of Environmental Protection (MA DEP) on September 28, 1999. This agreement marked the first approach to implementing an environmental management system targeting laboratory waste management at colleges and universities.

3.2 The Project Sponsors

Each of the following participating schools operates research and teaching laboratories at their respective campuses:

Boston College: The University's 116-acre main campus is located in an open suburban setting six miles from downtown Boston. Boston College is a coeducational university with an enrollment of 8,900 undergraduate and 4,600 graduate students. The university confers more than 3,800 degrees annually in more than 50 fields of study through 11 schools and colleges. Its 641 faculty members are committed to both teaching and research, and have set new marks for research grant awards in each of the last 10 years. Boston College has approximately 130 research and teaching laboratories and is classified as a small quantity generator (SQG) under RCRA. For 2001-2002 Boston College has five full-time equivalents (FTEs) staff responsible for managing the environmental, health and safety aspects of its campus.

University of Massachusetts Boston (UMB): UMB is one of five campuses of the University of Massachusetts. UMB is an urban university that provides teaching, research, and extension service. Programs include liberal arts and professional programs on the graduate and undergraduate levels, as well as doctoral programs that address issues of particular importance to urban environments and people. The campus currently supports 887 faculty members and 12,482 students in the 2000-2001 academic year, a combination of both part and full-time students. UMB has 140 operating laboratories on campus and is considered to be a Large Quantity Generator (LQG) because the laboratories surpass the 1-kilogram (2.2-pound) per month generation threshold of acutely hazardous waste under a certain RCRA regulation. There are 3.5 FTE staff in the EHS office who deal with Hazardous Waste, Chemical Handling, Fire Safety, Indoor Air, Emergency Preparedness, Lab Safety, etc. There is one 0.5 FTE person in Radiation Safety that is not tied to the EHS Office.

University of Vermont (UVM): UVM is located in Burlington, Vermont's largest city, with a population of 40,000. UVM's campus houses nearly 100 buildings on a 425-acre main campus. UVM also has off-campus grounds consisting of: four research farms; nine natural areas, including the summit of Mount Mansfield; Rubenstein Ecosystem Science Center on Burlington's waterfront; and several regional education centers. The university has approximately 10,000 students and 928 full-time and part-time faculty. The university has eight distinct colleges and schools; a graduate college; a medical college; and a continuing education division and offers more than 90 undergraduate majors; 4 pre-professional programs; 72 master's and 20 doctoral degree programs; and a medical program. UVM has a RCRA Part B storage permit and is also a large quantity generator (LQG) as the laboratories and other sources generate more than 1,000 kilograms (2,200 pounds) of RCRA hazardous waste in a single month. UVM has 6.75 FTE at UVM who deal with biological and safety issues and 5.5 FTE who address radiation safety issues on campus.

[6] The C^2E^2 is http://www.c2e2.org.

A summary of the schools and their laboratory activities are summarized in the table below (see Table 1).

Table 1: The locations, student bodies and approximate number of laboratories for each of the three participating universities.

University	Location	Student Body	Approximate number of laboratories
Boston College	Chestnut Hill, MA	14,000	130
University of Massachusetts-Boston	Boston, MA	13,000	140
University of Vermont	Burlington, VT	10,000	525

3.3 The Experiment

The principle objective of this Laboratory XL project is to pilot a flexible, performance-based system for managing laboratory waste. This performance-based system is developed around a Laboratory Environmental Management Standard (Laboratory EMS), which defines the criteria for the effective management of laboratory wastes. To achieve the objectives outlined in the Laboratory EMS, the universities are testing a two-part regulatory model which includes: (1) Minimum Performance Criteria for the management of laboratory wastes and (2) the development of a Laboratory Environmental Management Plan (EMP) which is a document that describes how each university will conform to the Laboratory EMS and the Minimum Performance Criteria. While the Laboratory EMS provides an overarching framework for the project, the unique facet of this program is the flexibility that each university has to tailor its EMP to the needs of its respective laboratories. This process is quite similar to the more universal concept of the Environmental Management System (EMS) that has been traditionally implemented in business, but is increasingly finding a home in local, state and federal governments. EMSs are being used with greater frequency to help integrate environmental considerations in day-to-day decision-making and practices and are designed to be part of the overall management system that includes organizational practices, procedures, processes and resources for developing, implementing, achieving, reviewing, and maintaining the environmental policy. An EMS provides a framework for managing environmental responsibilities, including regulatory compliance. The idea is that by improving overall environmental performance and placing more emphasis on pollution prevention, EMSs can also help organizations move beyond compliance.

The two-part model Laboratory EMS is further described below:

Laboratory Environmental Management Plan (EMP): The Laboratory EMS requires that each university develop and implement an EMP for chemical waste disposal. It is through the Laboratory EMP that the universities will have an opportunity to design a performance-based system which complements the OSHA requirements, encourages waste minimization and the active redistribution and reuse of laboratory waste. The Laboratory EMP is similar to the OSHA-required Chemical Hygiene Plan (CHP), which will enable some of the current RCRA hazardous waste regulations to more closely reflect current OSHA regulations, reducing confusion and ambiguity within the university laboratory setting. This project tests to see if, as a result of the harmonization of the OSHA CHP and the RCRA-oriented EMP, the new system will actively encourage chemical reuse and recycling, reduce costs, increase efficiency, and better educate laboratory professionals, researchers, and students. In addition, the new system is expected to provide a better management approach for laboratories and result in increased pollution prevention while still ensuring protection of human health and the environment.

Minimum Performance Criteria: In order to ensure the proper handling and management of laboratory waste, each laboratory must meet the minimum performance criteria defined in the Laboratory EMS and addressed in the Laboratory EMP. The elements of the Minimum Performance Criteria address criteria for labeling of laboratory waste, proper storage and containers for waste, duration of waste storage, and emergency response procedures in case of accidental releases of waste.

It is anticipated that the model being tested will yield superior environmental performance, beyond that which is achieved by the current RCRA regulatory system in the following three key areas, which will be described in greater detail in Section 6:

(1) Setting of Environmental Objectives and Targets and Pollution Prevention;
(2) Streamlining the Regulatory Process to Achieve Better Waste Management; and
(3) Promoting Greater Environmental Awareness.

3.4 The Regulatory Flexibility

Achieving superior environmental performance for this project requires flexibility in two areas of the RCRA statute involving (1) hazardous waste determination and (2) hazardous waste satellite accumulation. As an incentive to achieve superior environmental performance at the participating universities, EPA's Office of Solid Waste, the Massachusetts Department of Environmental Protection (MADEP), and the Vermont Department of Environmental Conservation (VTDEC) are allowing for more flexible and cost-effective processes under RCRA.

To enable this XL project, flexibility for the universities' compliance with RCRA regulations was addressed by a new site-specific rule for 40 CFR part 262, Subpart J, published by EPA in the September 28, 1999, *Federal Register*. In addition to addressing the two areas for regulatory flexibility, the new subpart also defines the Laboratory EMS. The regulatory flexibility agreed to under this project is termed a "conditional temporary deferral" that will expire on the FPA termination date and is only effective as long as the universities comply with the Laboratory EMS, including the Minimum Performance Criteria, and the requirements for the Laboratory EMP. State regulatory requirements in Massachusetts and Vermont parallel the Federal RCRA requirements for hazardous waste, and therefore, state regulatory relief is also addressed under this XL agreement.

In March 2000, VT DEC made revisions to the Vermont Hazardous Waste Management Regulation that exempts UVM from certain requirements of Sections 7-202, 7-301, 7-303, 7-305(b), and 7-310 of the state regulations. VT DEC is the primary regulatory agency overseeing UVM's EMP. The MA DEP promulgated a state specific rule that incorporated the terms of the Federal rule in May 2001. The state-specific rule provided increased regulatory flexibility and allowed Boston College and UMB to proceed with the project.

Hazardous Waste Determination

According to 40 CFR Part 262.102, *Laboratory Waste* means a hazardous chemical that results from laboratory scale activities and includes the following: excess or unused chemicals that may or may not be reused outside their laboratory of origin; hazardous chemicals determined to be RCRA hazardous waste as defined in 40 CFR Part 261; and hazardous chemicals that will be determined not to be RCRA hazardous waste pursuant to Part 262.106.

The universities believed that hazardous waste determination might be made prematurely in the laboratories and early characterization of a chemical, as waste may be a barrier to the reuse, recycling and redistribution of laboratory waste throughout the institution. Once researchers and graduate students no longer have use for an individual laboratory waste, they are seldom aware of the reuse and recycling opportunities available in other laboratories. Thus, they label even reusable materials "hazardous waste." The result is that a certain quantity of reusable material is unnecessarily disposed of every year. Under the current RCRA/OSHA regulatory scheme, a 1996 survey revealed that university laboratories currently reuse less than 1 percent of laboratory waste[7]. Therefore, identifying a central location where a trained environmental professional who has primary responsibility for all laboratories makes the formal determination as to the potential reuse or recycling opportunities for laboratories at the institutional level, is believed to increase the reuse and recycling of laboratory waste.

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[7] *New England Universities' Laboratories Project XL Final Project Agreement.* Available at http://www.epa.gov/projectxl.

This site-specific rule permits the hazardous waste determination to take place at a centralized facility within each university, potentially increasing the likelihood of reuse and recycling of materials. Under this XL project, the participating universities formally defer the hazardous waste determination from the laboratory to a central on-site location. The conditional temporary deferral covers laboratory waste.

Hazardous Waste Accumulation Time.
The satellite accumulation provisions of RCRA, 40CFR 262.34(c) require that hazardous waste in excess of 55 gallons be removed within three days of reaching the 55-gallon limit and some state rules are more stringent, requiring the removal of any full container within the three day timeframe. The universities have found that the three-day limit on the satellite accumulation of hazardous waste is often too short and not very practical in a university laboratory setting. This results in the EHS professional spending a great deal of time picking up and transporting full containers of laboratory waste on a constant, but somewhat unpredictable basis. The current system results in reactive and episodic pick-ups which, in a setting of over one hundred laboratories becomes time-consuming and inefficient for laboratory and EHS personnel and takes the place of other pressing EHS activities. The extension of three days accumulation is extended to 30 days to allow for EHS professionals to collect and remove laboratory waste during planned, systematic and scheduled intervals.

The change in waste management allows for the development of infrastructure and training designed to increase waste minimization and foster an organized and coordinated campus-wide chemical reuse system. Regular inventories of laboratory chemicals and the additional hazardous chemical training, including pollution prevention and environmental management practices, received by laboratory workers will help ensure that chemicals stored within the laboratory do not pose additional risks to laboratory workers.

3.5 Potential for System Change with the Labs XL
Project XL provides EPA with opportunities to test and implement approaches that protect the environment and advance collaboration with stakeholders. The innovations and potential system changes emerging from the NEU Labs project are described below.

Alternative Regulatory Approaches to Encourage Hazardous Waste Recycling and Reuse. By providing regulatory flexibility to the participating universities in conjunction with the EMPs, EPA and the State agencies are evaluating the effectiveness of flexibility in hazardous waste determination and temporary holding in encouraging the more efficient utilization of resources at the university level and thereby increasing recycling, reuse and pollution prevention efforts. The information gained on this approach and through this evaluation may be used by EPA to develop a framework to address the potential transferability of this type of regulatory flexibility to colleges and university laboratories nationwide.

Development of a Performance-based Environmental Standard for University Laboratories. The project is being conducted over a period of four years, and performance is evaluated annually based on the institution's reuse/redistribution of hazardous chemicals from laboratories, generation of hazardous waste, management system audits, and laboratory worker environmental awareness surveys. In light of the environmental performance of the three universities and the lessons learned from this pilot project, EPA, with stakeholder input, are using the information to determine whether an environmental standard for laboratories could serve as a national regulatory alternative.

3.6 Stakeholder Participation
Both national and local stakeholder have been involved in the development of the Laboratory EMS and substantive elements of the FPA. The initial stakeholder group, involved in FPA development, was a national assembly of experts in laboratory chemical and environmental safety. The purpose of this group was twofold: (1) to ensure that the NEU Labs proposal reflected state-of-the-art thinking with regard to controlling the

potential impacts of laboratory chemicals and (2) to ensure that the Laboratory EMS developed by the XL participants could over time reasonably apply to a broad spectrum of colleges and universities.

The development of the XL project was discussed at two broader based national stakeholders' meetings sponsored by C^2E^2. These meetings included representatives of different-sized colleges and universities, non-governmental organizations, industry, and various branches of the EPA. People unable to attend the national stakeholders' meetings were able to review the various drafts of the NEU Labs proposal on the XL web page on the Internet and comment electronically through the NEU Labs e-mail listserv. Additionally, copies of the XL proposal were mailed to individuals or organizations upon request. More than 100 people reviewed the proposal in this way. In addition, local stakeholders, such as university faculty, staff, and students, community stakeholders, and regulators with jurisdiction over laboratories have been involved through local meetings, presentations, or reviewing the NEU Labs proposal to ensure protection of laboratory worker and public health and safety under the proposed project. As this XL project is being implemented, the stakeholder involvement program ensures that interested parties are apprised of the status of project implementation and that national and local stakeholders have access to information sufficient to judge the success of this pilot, through local and campus newspapers, the Internet, and open meetings. The evaluation will be available to interested stakeholders. The draft results of this evaluation were presented at an international meeting in Toronto, Canada in July 2002 sponsored by the Campus Safety, Health and Environmental Management Association.

XL Stakeholder Spin-Off Benefit. An interesting aspect of this stakeholder development has been the evolution of a larger effort to describe the "Environmental Footprint" of UVM through the collection of environmental indicators. UVM applied for and received an EPA Technical Assistance Grant (TAG) in September 2001. The grants are available to Project XL sponsors through a cooperative agreement with the Institute for Conservation Leadership. The TAG was based on UVM's finding that local stakeholders were not focused on learning solely about laboratory hazardous waste management, and were more interested in looking at hazardous waste management as part of a holistic set of environmental indicators for the university. Local community organizations have been involved with the environmental footprint study as consultants. UVM's Environmental Council—comprised of students, faculty, and staff—reports to the President and is an active group for the XL project and for the indicators work that is ongoing. The results of the NEU Labs project will be aggregated as part of the indicators study.

Section 4 Evaluation Approach and Methodology

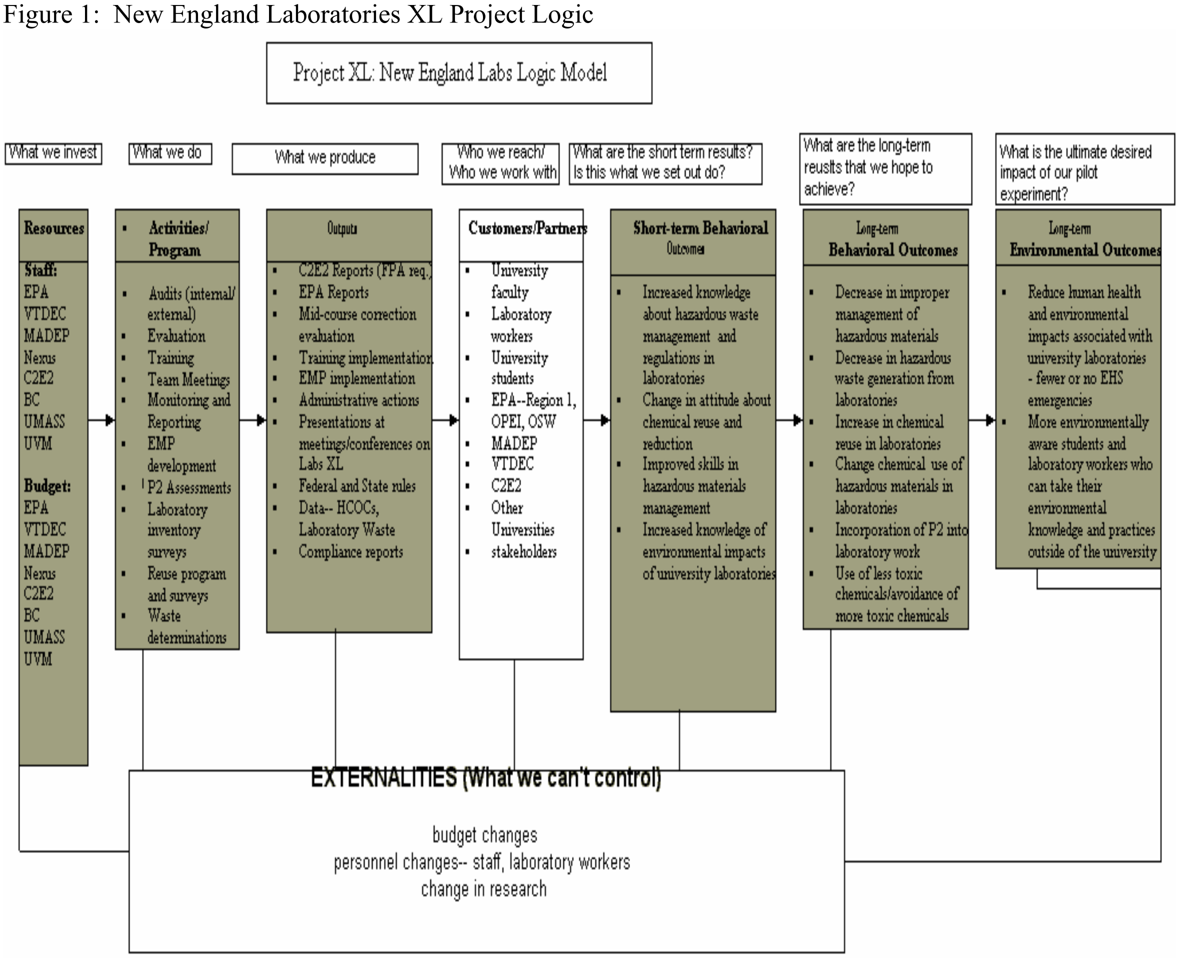
4.1 Evaluation Purpose

The project reached the midpoint (September 2001) from the formal date that the FPA was signed by participating parties and the project officially entered the implementation stage. The FPA for the New England Labs project is expected to terminate in September 2003, if there is no extension. The goal of this mid-term evaluation is to garner lessons learned from the unique approach of the NEU Labs project and to highlight opportunities to improve the overall environmental performance for the universities for the remainder of the project. In the course of examining this project over the past two years this paper describes the unique environmental management problems that universities face and ways in which this pilot attempts to ameliorate inefficiencies and make environmental gains. An inherent part of telling the story of the experiences of these universities is detailing the status of the universities in achieving environmental compliance and the superior environmental performance goals of this project. Section 8 of this mid-course evaluation describes how the university specific environmental plans were formulated and implemented.

EPA, the universities, C^2E^2, and the State agencies are all partners in the evaluation and jointly formulated the objectives and the goal of the evaluation. In the course of formulating an evaluation plan the group also laid out a framework for understanding the NEU Labs project with the use of a logic model. A logic model is a graphical representation of the logical relationships between inputs into the program, outputs of the programs, and what the intended outcomes of the program. The logic model for the NEU Labs project is presented in Figure 1(a full-page logic model is in Appendix 1).

An important element to note in the logic model is the unique partnerships between regulators—both federal and state—and the regulated community that are driving the project activities and outputs. For the two years that this project has been in existence, much good work has been done to complete the infrastructure necessary to support the pilot. The logic model helped visually document and outline the various "front-end" pieces of the project to which a project manager at first glance responded by saying, "we have really accomplished a lot!" This evaluation will help lead to a more targeted focus on the outcomes and recommend some tangible solutions for achieving long-term environmental outcomes such as to increase the understanding of environmental regulations and foster environmental awareness among Administrators, faculty, staff and students.

Figure 1: New England Laboratories XL Project Logic



4.2 Evaluation Methodology

A substantial part of the data collected for this evaluation is qualitative in order to gain an understanding of why and how certain aspects of the project are working and why certain long-term environmental objectives may face realistic hurdles in the laboratory setting. A section of this report is dedicated to describing the EMP in detail—the key document used to manage environmental performance at the universities. EPA, with assistance from its contractor, Industrial Economics, Inc. (IEc.) conducted a conference call on the EMP development and implementation phases with the key EHS staff from the three universities and Nexus Environmental Partners on March 5, 2002. EPA also conducted an additional call on EMP development and implementation with the VT DEC on March 7, 2002 as VT DEC is the primary regulatory agency overseeing UVM's EMP.

In an effort to gauge how well the EMP was working in the laboratories, EPA and IEc conducted group discussions based on a standard set of discussion questions at each of the three universities. The universities invited faculty, administrators and students to the group discussions. The format and questions asked of the groups at each school varied depending on how many participants were present. For example, at UMB some students were stopped in their research laboratories and if students were available, IEc asked them specific questions related to training and the EMP. Summaries of the group discussions and the questionnaire are presented in Appendix 2.

As this sector was not inspected on a regular basis by EPA and was not targeted for enforcement by EPA until approximately 10 years ago, a wealth of information does not exist on "typical" laboratory behaviors under the current regulatory scheme. Therefore, data on the three XL universities was collected soon after EMP implementation through announced audits. The audit information is wholly related to RCRA compliance under 40 CFR Part 262 Subpart J. The audits are preliminary and should serve as a baseline data for future audits for this project under the flexible regulatory scheme. Compliance data on non-XL universities was gathered in an effort to compare to the first year audits performed at the participating universities.

Section 9 examines the progress made in meeting the environmental performance indicators and the superior environmental performance requirements outlined in the FPA. The data for this section was compiled by the three universities in an annual progress report and submitted to EPA New England, as required by the FPA, in 2001 and 2002. The reports are available on the Project XL website at: http://www.epa.gov/projectxl/nelabs.

4.3 Evaluation Utilization

This mid-term evaluation should not be interpreted to be a summative evaluation on the merits of regulatory change for laboratories. The NEU Labs program is an innovative approach to laboratory management not only for the universities but also for the Federal and State regulators involved. This project is just one type of pilot for laboratories and is not intended to exist in a vacuum. This evaluation reviews one of a few pilot approaches being tested throughout the country and will eventually feed information into potential future regulatory innovation. Most importantly, it outlines efforts that EPA, the States, and universities can take to move beyond compliance with regulations to improve overall environmental performance. Although there are inherent difficulties in achieving a holistic evaluation based on short-term data, the findings of this study can be supported by prior work done on laboratory management.

The utility of this mid-term evaluation is in identifying the strengths and weaknesses of the NEU Labs program, offering suggestions for continuous improvement, and creating a system of learning within EPA, the States, and the universities on laboratory innovation. The intended users of this evaluation are not only the three XL universities, but also the larger universe of academic institutions all grappling with similar environmental management and regulatory issues. It is for this larger audience that the evaluation provides more background information on EMP development and structure so that pieces of this NEU Labs experiment, if applicable, may be replicated in other institutions. In addition, this evaluation should be useful to various offices of the EPA, as it will inform a national dialogue on the potential for regulatory reform for academic laboratories.

Section 5 Project Design and Implementation

5.1 The Workings of the New England University Laboratories Project

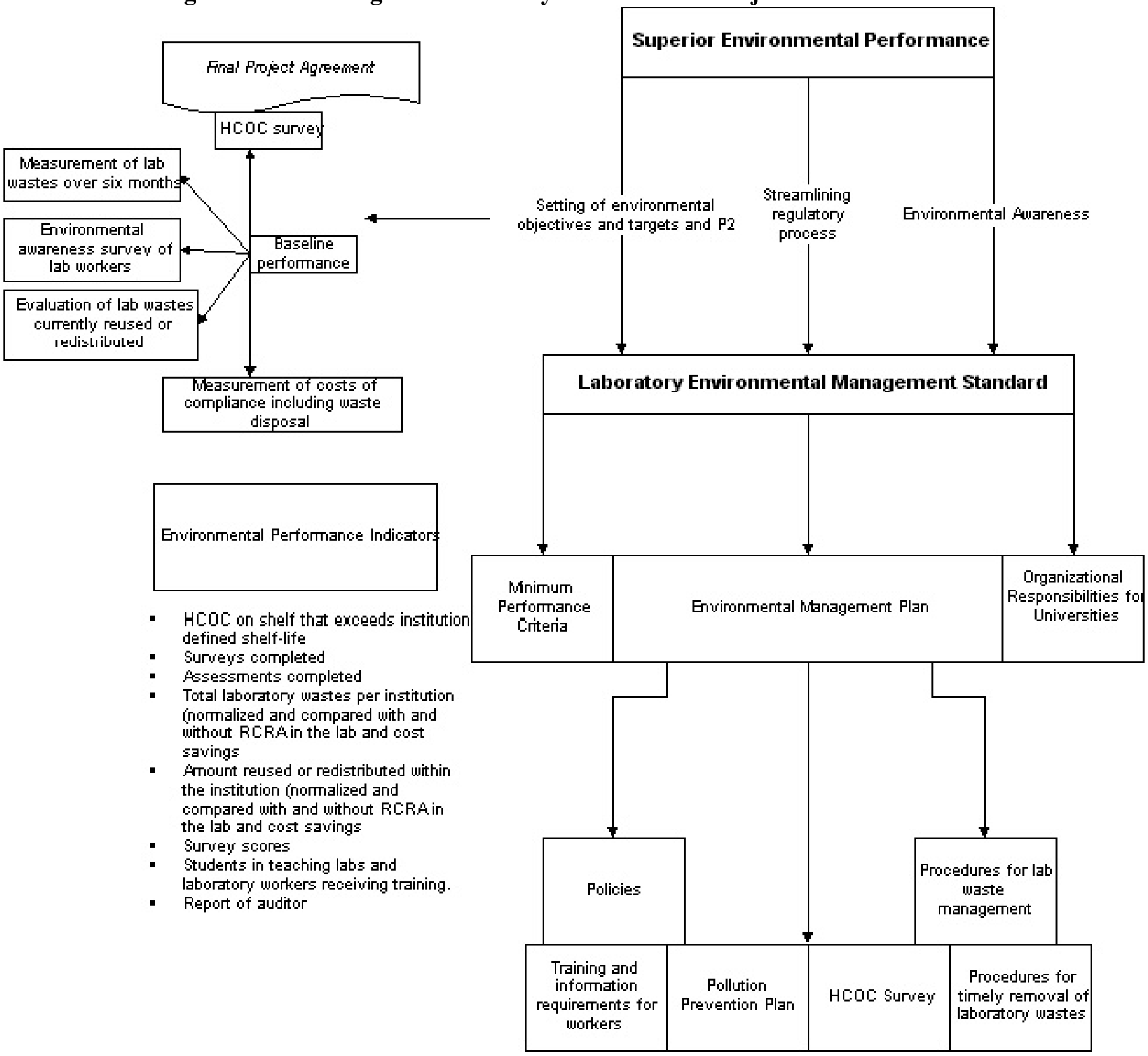


Figure 2: Diagrammatic representation of New England Laboratories project outline.

5.2 Project Implementation

The implementation of the project has been divided into six phases and is structured in the following manner:

Phase 1: Development of baseline assessment: Each university conducted a baseline assessment of environmental performance, based on representative data. Baseline environmental performance included identification of hazardous chemicals of concern, measurement of laboratory waste reuse and redistribution and hazardous waste generation data from laboratories.

Phase 2: Development of Laboratory EMP: Each university, working in collaboration with the federal and State agencies, developed EMPs that included policies, procedures, and practices consistent with the Minimum Performance Criteria and the Laboratory EMS.

Phase 3: Review by Project Signatories and Stakeholders: The written EMPs were provided to EPA, and the applicable State agency, for review and comment to ensure that the requirements of the Laboratory EMS have been met. A copy of each university's EMP was made available to individual stakeholder groups.

Phase 4: Training and Information: Each university provided laboratory workers with initial training and information on the EMP and continues the training throughout the life of the project.

Phase 5: Project Implementation: Each university notified EPA and the relevant state agency in writing when it was prepared to implement its approved EMP. Up until such written notification, RCRA regulations (or the equivalent State regulations) applied in full.

Phase 6: Monitoring, Reporting and Evaluation: Currently, the universities are in Phase 6 of their project implementation plan. Each university is responsible for collecting data and monitoring its environmental performance using the EPIs selected for the project.

Section 6 Anticipated Superior Environmental Performance

As mentioned above, the NEU Labs project seeks to achieve superior environmental performance, beyond that which is achieved under the current RCRA regulatory system, in three areas, which are further described below:

6.1 Setting of Environmental Objectives and Targets and Pollution Prevention

The systematic approach to environmental management sets the stage for better tracking, control, goals setting and pollution prevention.

(a) General Scheme: The Laboratory EMS is a significant improvement over the current regulatory requirements in that it requires (i) an institutional commitment in the form of a university policy to prevent pollution, (ii) a procedure for conducting an annual survey of hazardous chemicals of concern (HCOC), and (iii) a better system to reduce the potential for hazardous chemicals to accumulate and become wastes. For example, each university's EMP must include or reference:

- A pollution prevention plan[8]
- Defined procedures for conducting an annual survey of laboratories that potentially store HCOC and that address removal of expired chemicals
- Defined procedures for conducting laboratory decommissioning (i.e., cleanouts)
- Defined procedures for the timely removal of laboratory wastes from the laboratory

(b) Increased Reuse of Laboratory Waste and Laboratory Waste Reduction: One area targeted for the demonstration of superior environmental performance is in the identification of laboratory hazardous chemicals and reuse of such chemicals. The current regulatory framework does not encourage researchers to identify chemicals as hazardous, nor does it encourage them to identify opportunities for reuse of the chemicals. This project commits the universities to achieve a 10 percent reduction in waste (from baseline values) and to increase reuse or redistribution of chemicals by 20 percent (from the measured baseline) over the life of the project.

(c) Annual Survey of Hazardous Chemicals of Concern: A tool included in the EMP to help researchers identify hazardous chemicals will be a required annual survey of hazardous chemicals of concern (HCOC) and a risk evaluation survey of the identified HCOC chemicals in the laboratory. Environmental, Health and Safety (EHS) professionals at each university generate the HCOC list based on regulatory concerns, risk concerns, and potential chemical reactions. The criteria at each university includes:

- Chemicals given an expiration date by the manufacturer due to safety considerations (e.g., peroxide forming chemicals, etc.)
- Chemicals which meet the RCRA definitions of reactive or corrosive and have been determined by professional judgment to present a risk to non-lab workers or the environment
- Poison inhalation hazard designation by the U.S. Department of Transportation (covers serious toxics)
- Other chemicals as determined by professional judgment to present a risk to non-lab workers or the environment

[8] EPA's definition of pollution prevention, or P2, includes the following: source reduction and other practices that reduce the volume or eliminate the creation of pollutants through the increased efficiency in the use of raw materials, energy, water or other resources, or the protection of natural resources by conservation.

- Chemicals may be removed from the HCOC list if there are insufficient quantities to pose a risk

The HCOC list is developed on a university-by-university basis, because the types of hazardous chemicals at a particular university will vary with the type of research work performed there. This project goes beyond the "waste" management regulations prescribed in RCRA by addressing this particular "upstream" issue at its source. It is expected that by providing regular and consistent data on chemicals and chemical storage, the surveys will support university-wide chemical redistribution and/or the timely disposal of hazardous chemicals that are approaching or have exceeded their shelf life. The survey documents whether the HCOC's remaining on the shelf have been assessed for product integrity.

(d) Ongoing Evaluations and Audits: Evaluations and audits are performed to help assure conformance with the university's EMP. Together with the enhanced environmental awareness training, internal audits/corrective actions provide a way to continually improve the Laboratory EMS and help achieve improved environmental protection.

(e) Compliance with Other Laws and Regulations: The universities continue to comply with all other Federal, State and local environmental laws and regulations not specifically deferred pursuant to EPA's site specific rule for this project and the legal mechanisms instituted by Vermont and Massachusetts.

(f) Corrective Action for Non-conformance: Each university's EMP contains corrective action procedures in the event that non-conformances are observed.

6.2 Streamlining the Regulatory Process to Achieve Better Waste Management

The requirement to define and implement laboratory waste management policies and procedures is aimed at the effective management of laboratory wastes at every stage of their handling and disposition, including full compliance with current RCRA requirements once laboratory waste is received at each university's on-site hazardous waste accumulation area. The Minimum Performance Criteria and the procedures for complying with them were written to ensure that enforceable safeguards would be in place. The result of a streamlined regulatory process is to shift the focus to waste at its generation points and to channel time and resources spent by universities on waste pick-up and handling to include pollution prevention and chemical substitution and reuse.

6.3 Environmental Awareness

Under the existing regulatory system, very little attention is paid to employee training, defining policies and procedures for waste management and handling, and enhancing audit programs and pollution prevention strategies as university staff are often focused on managing laboratories for regulatory requirements. With this project, laboratory workers receive enhanced hazardous chemical training with respect to laboratory waste, pollution prevention, and the environmental practices at the university. The training requirements are outlined in the Laboratory EMS. The universities also hope that the training will instill a long-lasting environmental awareness in its students as they graduate and that will carry with them as they pursue different careers.

Section 7 The Laboratory Environmental Management Standard

The Laboratory EMS consists of 4 components:

1. The Minimum Performance Criteria;
2. Requirements for the University's Environmental Management Plan;
3. Organizational responsibilities for the University; and
4. Training and information requirements for laboratory workers.

7.1 Minimum Performance Criteria

The Minimum Performance Criteria (MPC) are specific requirements, pertaining to laboratory activities and wastes that must be met by laboratory workers to assure that the XL regulation is achieving a level of protection exceeding that achieved by traditional RCRA regulations. The minimum performance criteria for all the participating universities are very similar to RCRA satellite accumulation requirements (40 CFR 262,100-106) and include:

- Labeling

- Threshold waste quantities
- Time limits on holding waste
- Maximum waste quantities that can be in a laboratory
- Container management requirements:
  - closure
  - condition
  - compatibility of contents
  - inspection requirements
  - prohibition of releases
- Emergency response requirements:
  - post notification procedures
  - appropriateness of equipment
  - notification procedures
- Corrective and preventive actions
- Transfer of laboratory wastes
- Training requirements

7.2 Environmental Management Plan

The Environmental Management Plan (EMP) describes the management system that the universities will implement to achieve compliance with the MPC. The EMP describes services provided by Environmental Health and Safety (EHS) staff, such as collection and management of laboratory chemical waste and tracking of regulatory requirements as well as policies of the university to show their environmental commitment. The EMP also includes management tools such as pollution prevention objectives and targets to help upper management assess the success of the University's hazardous waste management program.

The EMP is written to meet the requirements of EPA and State Agency site-specific regulations for the NEU Labs Project. The goal of the EMP is to continuously improve the universities' environmental performance with regard to the management of chemical wastes from its laboratories. The plan outlines the roles and responsibilities of various groups in the campus community in meeting this goal. It describes specific procedures that laboratory workers and supervisors will follow in order to assure that laboratory waste is properly managed in accordance with the Minimum Performance Criteria of the site-specific Project XL rule. Procedures for identifying and taking advantage of opportunities for hazardous waste minimization and pollution prevention are also included. Finally, it describes the training and information mechanisms that will be used to assure that laboratory workers are aware of and comply with the requirements of this plan.

7.3 Organizational Responsibilities

The organizational responsibilities described in the regulation are the administrative steps that must be taken to assure that the EMP is successfully implemented. These steps are included within the EMP.

7.4 Training and Information Requirements

The training and information requirements stipulated in the regulation assure that laboratory workers and visitors throughout the university are aware of the university's hazardous waste management and pollution prevention program.

7.5 Environmental Performance Indicators

Environmental Performance Indicators (EPIs) were not included in the regulation, but are a critical component of the FPA. The EPIs are measures to track each university's success at meeting its environmental goals with respect to laboratory waste management. As part of the FPA, the environmental performance at the universities is measured against specific environmental goals and the EPIs. The EPIs are classified by type—pollution prevention, compliance (e.g. streamlined regulatory requirements) or environmental awareness. To get an accurate picture of performance the EPIs are compared to baseline assessments completed at each university. The baseline assessments include the following factors:

1. A survey of hazardous chemicals of concern and quantity stored on the shelf in those laboratories covered by this project.

2. A measurement of laboratory wastes generated during a defined time period (e.g., over a six month period).
3. An environmental awareness survey of laboratory workers.
4. An evaluation of the amount of all laboratory wastes currently reused or redistributed (note: each university currently estimates this rate (less than one percent) as consistent with data collected in a 1996 survey of 100 academic institutions by the Campus, Safety, Health and Environmental Management Association.
5. A measurement of costs of compliance that includes available information on waste disposal costs.

The environmental goals and indicators presented below, incorporate the superior environmental objectives and corresponding baseline measures into the overall EPI measurement system. In order to measure whether the universities are reaching their stated environmental goals and achieving superior environmental performance above current performance, the results can be compared to the baseline assessments that were conducted in Phase 1.

Table 2: Environmental Goals and Indicators for the NEU Labs project as described in the FPA.

#	*Performance Type*	*Purpose*	*Environmental Performance Indicators*	*Goal*
1	Pollution Prevention and Risk Reduction	Annual surveys of Hazardous Chemicals of Concern (HCOC)	HCOC on shelf that exceed institution defined "shelf-life"	All HCOC on shelf are within defined "shelf-life"
2	Pollution Prevention	Verify annual surveys of HCOC	Surveys completed	100% completion of surveys each year
3	Pollution Prevention	Conduct P2 opportunity assessments	Assessments completed	One opportunity per laboratory per year
4	Pollution Prevention	Measure hazardous materials reuse and redistribution	Amount reused or redistributed within the institution (normalized and compared with and without RCRA in the lab) and cost savings	Twenty percent increase in reuse/redistribution from baseline over life of project (with attendant reduction in waste disposal)
5	Pollution Prevention	Measure laboratory waste generation rates	Total laboratory wastes per institution (normalized and compared with and without RCRA in the lab) and cost savings	Ten percent reduction of hazardous waste from baseline over life of project
6	Environmental Awareness and Risk Reduction	Assess environmental awareness of laboratory workers	Survey scores	Scores demonstrate improvement over life of project (note: the same people will not be necessarily be tested)
7	Environmental Awareness	Provide environmental awareness training to a more diverse group	Students in teaching labs and laboratory workers receiving training	Increase number or percentage of students and lab workers receiving training

#	*Performance Type*	*Purpose*	*Environmental Performance Indicators*	*Goal*
8	Compliance	Evaluate environmental management program effectiveness	Objectives and targets	Achievement of objectives and targets
9	Compliance	Audit environmental management plan conformance	Report of auditor	Report improvement

Section 8 University-Specific EMPs

The EMP approach is based on holistically managing laboratory operations to improve environmental performance. Since this idea is new to this unique sector of university laboratories, the specifics from each university's EMP are presented in Appendix 3. As the EMP is the guiding document and the implementation plan against which success will be measured, it is equally important to understand the EMP components. The descriptions of the EMPs (in Appendix 3) highlight areas of university administration involvement and structure of how the EMP is administered, definitions of laboratory wastes and goals for reducing or reusing chemical wastes, and unique approaches to HCOCs and training.

Each EMP also reflects the scope and institutional culture of each university. These two factors are important considerations in creating an environmental management system (EMS) and can be considered important drivers of creating an EMS. EHS staff at the three XL institutions provided supplemental information on the EMPs and EMP process that is reflected below. The goal of this section is also to document each university's methodology for developing an EMP and process for EMP implementation so that academic institutions of similar size and culture may replicate this EMS approach to laboratory management.

8.1 Boston College

The EMP at Boston College was completed in July 2000. Boston College developed an environmental policy that commits to compliance and was signed by the President of Boston College. Due to a personnel change in the EHS office, there was some adjustment time with the EMP implementation; however, the EMP was slated for implementation in September 2000. The EMP development at Boston College was an internal exercise to create a performance-based document by pulling together existing policies, information and EHS forms. The EHS office had the main responsibility of crafting the document and relied on one of two committees for review and endorsement of the EMP. The Oversight Committee consists of a cross-section of the faculty and a strong Administration presence, which includes the following individuals: facility managers, research directors, legal advisors, risk managers, research deans, the Vice Provost of Finance, and a community affairs representative. As the panel was very inclusive, controversial issues were channeled to the right people to avoid time-consuming delays later in the process. The second committee active in EMP development was the Chemical Hygiene/Environmental Management Committee, which consists of members of the university's scientific community. This committee is an ongoing vital force that motivates those that work within labs to participate in XL-related activities.

EPA—New England also reviewed the Boston College EMP in accordance with the provisions of the FPA. Comments were provided at meetings and by memo on the Boston College Draft EMP in March 2000. Comments on the final EMP were provided by letter in May 2000.

The EHS staff manages and maintains the EMP, including necessary resources—staff and finances—needed to implement and monitor the EMP. There were no additional financial investment costs incurred for daily expenditures above budget for the EMP. Funding activities for the EMP included hiring one person to complete the HCOC survey, and there are costs that EHS had allocated in its budget for circulating and collecting the awareness survey and other EMP development proceedings, and working with the hazardous waste vendor to assist with laboratory audits.

Once it was implemented, Boston College posted its EMP on its website at: http://www.bc.edu/bc_org/fvp/ehs/emp_partone.html. The EMP is divided into the following six categories:

(1) Administration; (2) Laboratory Wastes; (3) Standard Operating Procedures; (4) Pollution Prevention; (5) Surveys of Hazardous Chemicals of Concern; and (6) Information and Training.

8.2 University of Massachusetts Boston

In 1997, UMB developed an environmental, health and safety policy, signed by the Chancellor of the university, that asserts its commitment to environmental health and safety and clarifies responsibilities for all administrators, faculty, staff, students and committees involved in environmental health and safety issues. The UMB plan focuses on the integration of the CHP and the EMP into a CH/EMP. The CH/EMP contained many elements from the CHP (which already had buy-in from the participating laboratories) so there was a level of familiarity with the document as a whole. The plan was written by the EHS Committee and had the endorsement of the whole group. C^2E^2 also provided input and assisted in the EMP formulation. The school has fewer labs and faculty relative to the other NEU Labs schools, so it was relatively easy for EHS to build on established relationships and trust and to answer questions in person about EMP development. This factor paved the way for EMP implementation. The Administration, including the Administrative and Finance Chancellors, approved the new CH/EMP document and had committed themselves to the process early on. In addition, the Chairs of the Departments were the champions of the EMP and were able to garner support for the EMP with the faculty. This was an important piece of the EMP implementation process as the Chairs influence and direct daily operations and staff in their departments.

EPA—New England also reviewed the UMB CH/EMP in accordance with the provisions of the FPA. Comments were provided at meetings and by memo on the UMB Draft CH/EMP in March 2000. Comments on the final CH/EMP were provided by letter in May 2000.

There were some minor start-up costs related to EMP implementation, but in general there was no need for additional significant resource inputs to implement the project.

The CH/EMP is divided into five main sections—(1) common elements of the UMB integrated chemical hygiene and environmental management (CH/EM) plans; (2) developing standard operating procedures; (3) operational material safety data sheet; (4) environmental management; and (5) pollution prevention. The complete CH/EMP can be accessed at: http://omega.cc.umb.edu/~ehs/ch_emindex.htm.

8.3 University of Vermont

The UVM EMP consists of a coordinated set of policy statements and implementation plans. The work to develop the EMP was conceptually designed before the FPA for the project was signed. The starting point was identifying waste forms that would apply to the EMP. Environmental Safety Facility (ESF) staff initiated EMP development in September 1999 and a draft was sent to the Vermont Department of Environmental Conservation (VT DEC) for review. VT DEC is the lead agency for RCRA compliance under the RCRA Partnership Agreement with EPA for oversight of the XL project for UVM and therefore was responsible for approving the EMP. Both EPA—New England and VT DEC reviewed the EMP during its development. VT DEC provided formal comments UVM in accordance with the FPA in April 2000 and EPA—New England provided formal comments to UVM in accordance with the FPA in May 2000. There is a unique requirement in the FPA for UVM that calls for approval of the EMP by the VT DEC. VT DEC approved the EMP in December 2000. Between 1999 and 2000, UVM and VT DEC had a number of informal discussions to clarify certain EMP elements. UVM faced some personnel changes during development of the EMP that lead to delays in finalizing the document. Before the project was implemented ESF met with both the Vice-President of Administration and the Vice Provost for Research to attain buy-in and support for the project. UVM had a development and review committee with the Chemical and Biological Safety Committee to assist with EMP development.

Each section of the UVM EMP includes assignment of roles and responsibilities, a specific procedure to be followed (described by a form and instructions for its use), and records that will be kept, when necessary. UVM has put forth a Policy for Management of Laboratory Waste that has been signed by the University's president and describes the University's commitment to regulatory compliance, waste minimization, risk reduction and continual improvement of the environmental management system. The EMP relies on a partnership between UVM laboratory workers and ESF staff. The EMP is divided into two main sections—the Laboratory Standard Operating Policies and Procedures and Administrative Policies and Procedures. The

Laboratory Standard Operating Policies and Procedures section is divided into five parts and utilizes elements of the CHP to define laboratory SOPs. The Administrative Policies and Procedures section of the EMP has nine parts that address training, HCOC, laboratory audits, decommissioning laboratories, hazardous waste identification, pollution prevention, tracking legal requirements, document control, and annual review of environmental performance. The EMP can be accessed on the Internet at http://esf.uvm.edu/uvmemp/.

Section 9 Measuring Performance with Environmental Performance Indicators

This section looks at the performance of the project through Environmental Performance Indicators (EPIs) set forth in the project's FPA. The universities committed to conducting a baseline assessment of environmental performance prior to the implementation of the Laboratory EMS, based on representative data, within the first six months of the effective date of the Final Rule with a report within nine months. The baseline assessment was completed on June 28, 2000. The progress of each school in meeting many of the EPIs should be measured in comparison to the baseline assessment. From 2000, the schools have been producing annual reports that detail each institution's progress in meeting the EPIs. Data collected for the baseline EPI, and 2000 and 2001 data are grouped according to the EPI. In general, the baseline information was more robust for certain indicators than others. In order to ascertain the level of progress, efforts should be made to ensure that the baseline information collected is complete and reflects quality data.

Because UVM implemented their EMP in December 2000, the December 28, 2000 First Year Status Update for the project did not contain much data and a decision was made to supplement the report. In April 2001, EPA New England met with the three XL universities and Nexus Environmental Consultants to discuss the format and information needs for the supplemental report. The report covered the topics of HCOCs, laboratory audits, pollution prevention, laboratory waste reduction and chemical reuse and recovery goals. In June 2001, the supplemental report was submitted and in September 2001, a follow-up meeting was held with participants from the three participating schools, Nexus Environmental Partners, MA DEP, VT DEC, EPA—New England, and EPA Headquarters. The September meeting focused on the EPIs and at the meeting, it was decided that EPA Headquarters, to assist the project in achieving its long-term outcomes, would conduct a mid-course correction evaluation. Additionally, a subcommittee formed to specifically evaluate different ways to look at compliance. That review results in a scorecard that can be used to assess EPI #9, which is presented in the discussion below.

The results presented below are based on the 2000-2001and 2001-2002 annual reports completed by the three institutions. The following sections detail the results of the mid-term review of the EPIs and presents findings and recommendations for the EPIs. Similar EPIs are grouped by relationship.

9.1 EPI #1 Goal: Outdated Chemicals of Concern and EPI #2 Goal: Hazardous Chemicals of Concern Inventory

Hazardous Chemicals of Concern (HCOC) on shelf that exceed institution defined "shelf life" (EPI #1). The goal of EPI #1 is to ensure that outdated hazardous chemicals of concern are appropriately removed from laboratory shelves and disposed. This EPI is a result of the observation that good housekeeping is an important hazardous waste minimization strategy for laboratories. A laboratory that tracks its chemical inventory carefully enough to prevent accumulation of outdated chemicals is very likely to avoid purchasing excess chemicals. EPI #1 is discussed jointly with EPI #2, below, in this evaluation.

Annual Surveys of Hazardous Chemicals of Concern (HCOCs) (EPI #2). EPI #2 examines each university's efforts to develop a methodology for conducting baseline HCOC risk assessment inventories. The exact HCOC lists are developed on a university-by-university basis, as the types of hazardous chemicals at a particular university vary with the types of research work performed there.

The schools have completed a good deal of work on these two EPIs. Meeting these EPIs is easier with the EMP in place as it clearly defines responsibilities of Principal Investigators (PIs) and laboratory personnel. However, this is an area where the universities have not yet accomplished the goals of the FPA (to have 100 percent completion of the HCOC surveys and to only have HCOC on the shelves that are within the university defined chemical shelf lives) for a variety of reasons that are outlined below. It is clear that there is a lot of ambiguity on the definition of outdated chemical shelf lives as expiration dates supplied by the manufacturer are often too conservative to encourage future purchases of chemical stocks and researchers make individual decisions on how long to use chemicals based on research needs. In addition, implementing a common HCOC procedure for the academic institution is difficult due to frequent turnover of staff, faculty and students.

Boston College: EHS developed the HCOC list to identify the shelf lives of certain chemicals that have specific shelf-lives (i.e., ethers and picric acid), however, laboratories determine shelf-lives for most of their chemicals. EHS also advises laboratories to examine chemicals from a housekeeping perspective and to remove chemicals not used for quality reasons. These materials (which are few in number) are wastes. The remaining materials are potentially useful. EHS then asks the laboratories to evaluate a chemical's degree of hazard versus the utility of having it on hand. The Boston Fire Department requires a complete inventory of hazardous chemicals in the laboratories so that they have a good understanding of chemicals stored and used in the laboratories in case of emergencies. Boston College completed its lists of HCOC in August 2001 and it was introduced in training in August 2001. The HCOC survey was conducted in two phases—the high hazard chemicals sweep and inventory audit.

In spring 2000, EHS requested that laboratories provide complete chemical inventories in accordance with requirements of the Boston Fire Department and to identify quality or need-based decisions on keeping each chemical in stock. Ninety percent of the laboratories were able to comply with the request at that time. The remaining laboratories were involved in a renovation project and were to complete their inventories after the moves. After the EPA Audit in April 2001, BC readjusted its approach to HCOCs. In addition to providing more specific information to labs about particular HCOCs, EHS began listing chemicals that require annual review. The list is based on the criteria of degree of hazard or stability or quality over time. In February 2002, Boston College hired a chemist from Onyx Environmental who did a physical audit of all laboratories to identify potentially unstable chemicals. The chemist identified approximately 40 containers that were recommended for disposal due to their ages or conditions. During summer 2002, the laboratories will be audited again to determine if the disposals took place.

The second phase of the HCOC audit was to develop a baseline for the laboratories to identify highly hazardous, though not necessarily reactive or unstable chemicals, through a scan of the inventories submitted by the laboratories. A student worker in the EHS department reviewed the inventories on file and highlighted the chemicals that were on the HCOC list. The laboratories were notified that certain chemicals should be assessed for ongoing usefulness, proper storage, and safety considerations. This will be undertaken along with the full inventory submission for Boston and Newton Fire Departments.

University of Massachusetts Boston : UMB is required by the Boston Fire Department to have complete chemical inventories for all laboratories and to conduct an annual inventory of chemicals. This list is reviewed on an annual basis and updated to ensure it covers an appropriate breadth of hazardous materials. Additionally, Principal Investigators are asked to evaluate peroxide-forming chemicals and nitro compounds when completing the Monthly Laboratory Self-Inspection Checklists. UMB has designated the following chemicals as HCOCs:

- EPA P-listed wastes
- OSHA special carcinogens
- OSHA teratogens/reproductive toxins
- OSHA designated highly toxic substances
- Explosive nitroarenes
- Peroxide-forming chemicals
- Pyrogens
- Shock-sensitive explosives

As of June 2001, UMB has not directly tracked the absence of outdated chemicals on laboratory shelves. Instead, EHS requires laboratories to conduct comprehensive inventories of all laboratories with which EHS highlights generic categories of HCOCs in training sessions. EHS believes that it has seen fewer outdated materials remaining on shelves and that there have been a decrease in the disposal amounts of these types of materials. In June 2001, the PIs were also asked to evaluate peroxide-forming chemicals and nitro compounds when completing the Monthly Laboratory Self-Inspection Checklists. These compounds are the most prevalent and problematic HCOCs on campus as once they are opened they usually have short self-lives unless they are regularly monitored and tested for peroxide presence. Nitro compounds must be monitored to insure that they contain at least 10 percent water or they become unstable.

UMB has identified eight classes of chemicals in its CH/EM plan and laboratory workers receive guidance with respect to the management of these chemicals during training. EHS has tagged or highlighted these materials on inventory sheets for each laboratory. In June 2001, the current system of conducting the chemical inventory underwent significant change. Under the old system, the EHS office generates a chemical inventory list for each laboratory from its database and sends the list to all PIs in August. PIs have one month to update lists, sign them, and return them to EHS for input into a central database. In the past, this manual process has taken an enormous amount of time for the PIs and EHS staff. The typical update time period from start to finish has taken as much as 18 months. To minimize this problem and create more accurate inventories, in March 2002 EHS implemented the ChIM 5.2, a new chemical bar code based tracking system on a lab-by-lab basis. UMB believes that the bar code system has speeded up collection of the inventories and provided EHS with more accurate and reliable data. The tracking system is anticipated to enhance the ability of EHS to identify pollution prevention opportunities. The new system should be more efficient and allow EHS to track chemicals from laboratory to laboratory.

EHS is testing the efficacy of the software with a pilot project based on the laboratories under the supervision of one professor, who oversees five active chemistry labs. The pilot was implemented in the fall of 2001, and has returned promising results, as EHS was able to monitor all materials and update the inventory as necessary with lab personnel. This suggests that the barcoding system will achieve the anticipated benefits of inventory management. The manual inventory will not be updated in order to complete the barcoding effort.

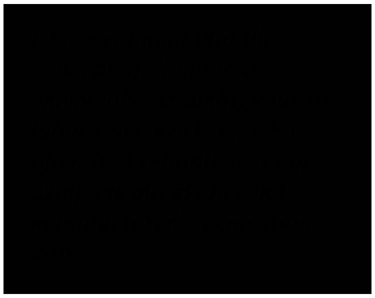
The next step for UMB is to network the program so that individual departments will have access to the inventories, which will allow them to update the system with new materials and search for chemicals when needed. By the end of summer 2002, for specific PIs, the EHS office will take inventory from each laboratory and generate Operational Material Safety Data Sheets for each laboratory. In addition, the inventory list will have HCOC's marked an explanation of what HCOCs will be included with each information package.

<u>University of Vermont:</u> UVM based its HCOC inventory on the requirements of the Superfund Amendments and Reauthorization Act (SARA) Title III reporting, which is now commonly known as the Emergency Planning and Community Right-to-Know Act (EPCRA). EPCRA was designed to inform emergency planners and the public of potential chemical hazards. The regulations were developed to provide the quantity of regulated chemicals at a facility, the specific hazards presented by the chemicals, the fate of chemicals (i.e., used, discharged, sold, etc.), and any unplanned releases.

The UVM HCOC survey process includes laboratory workers identifying and disposing of outdated materials while completing the form on an annual basis. A variety of regulatory chemical lists were reviewed in 1990 to generate a list of approximately 400 hazardous chemicals considered to be of potential environmental or safety risk and likely to be found at UVM. The list is distributed to laboratories every January, and the laboratories report the quantity of each chemical on the list that is stored there on a daily basis, which are then rolled up into cumulative totals. This process provides a way for emergency responders to plan for potential responses to campus buildings by identifying those buildings with significant amounts of hazardous laboratory chemicals.

Both internal and external audits have revealed that a large number of excess chemicals were in storage in the Chemistry Department stockrooms and in the Agricultural Biochemistry stockrooms. UVM contracted with Heritage Environmental, Inc. to inventory, package and dispose of these chemicals. This work was completed in July 2001 and cost UVM more than $25,000.

In June 2001, ESF staff also focused on the management of outdated HCOCs in the College of Medicine. Approximately 50 laboratories within the College of Medicine were decommissioned, moved or renovated. As these rooms emptied, ESF staff provided clean-out assistance to the laboratory workers to facilitate excess chemical disposal. Twenty-three laboratories from the College of Medicine asked for this assistance.



In June 2001, UVM had a HCOC survey procedure in place, but had not yet determined how best to use the survey process to measure the numbers of outdated chemicals on laboratory shelves. ESF staff have found that the concept of "outdated chemicals" as it is ambiguous to lab workers, who often find reliable ways of using chemicals beyond manufacturer's expiration dates. ESF is investigating ways of developing a more quantitative approach to tracking outdated chemicals. The 2001 UVM HCOC survey was administered between February 1, 2001 and March 31, 2001. For 2001, ESF changed its survey procedures and distributed survey forms on a room-by-room basis, along with other EMP implementation forms, rather than giving survey forms to the laboratory supervisor. ESF originally organized laboratories for the HCOC survey based on lab supervisors primarily because laboratory chemicals are commonly assigned to a particular laboratory supervisor and move between laboratories under his/her control. ESF decided to change its approach in 2001 because it believed that more laboratories would be included under the room-by-room distribution approach. Participation in the 2001 HCOC survey was disappointing for ESF. Only 251 labs out of 538 laboratories submitted HCOC forms in time to be included in the SARA Title III submission. This number represents 45% of the universe of UVM's labs and is below the historical HCOC survey return rate of 60 to 80 percent. ESF believes that the lower response rate was due to distribution of five new forms (needed to implement the EMP) at the same time as the HCOC survey form and that the information requests detracted attention to the HCOC survey. In addition, many laboratories in the College of Medicine did not complete the inventory forms as they were anticipating a move within three months and were expecting to conduct significant chemical clean-outs as part of their efforts. Lastly, many supervisors preferred the older approach and combined their laboratories into one form. For 2002, UVM returned to its laboratory supervisor management approach for HCOC inventories.

UVM has been tracking the trends in chemical inventories per UVM laboratory for the years with available data since 1994 (see Table 3)[9]. Of interest for EPI #1 are the columns labeled "Chemical Count per Lab," which presents the average number of different chemicals found in labs and "Total Pounds of HCOC" shows the total weight of these chemicals. These two columns indicate that both the average number of chemicals and the total amount of chemicals being stored in UVM laboratories have dropped by approximately one-third since the implementation of the EMP. This drop is statistically significant within the variation shown by these numbers over the history of the inventory. The increase in these numbers from 2001 to 2002 is not outside the historical standard deviation for this measurement.

ESF attributes the decrease in the amount of HCOCs in the laboratories to the "chemical safety surveys" (1998-2000) and safety audits (2001) conducted by ESF staff that increased attention to the chemical inventory management process. Specifically, these lab visits emphasized increasing lab workers' understanding of the problems associated with outdated chemicals. ESF attributes the increased survey response rate for 2002 to increased training, better survey distribution methods, and increased follow-up with laboratories. For example, in 2002, ESF sent two email reminders to laboratory supervisors, and this effort helped double the return rate in 2002 over 2001.

Table 3: HCOC Inventory Trends at UVM

Year[10]	Forms Distributed	Rooms Reporting	Lab Supervisors Reporting	Supervisor Response Rate	Chemical Count per Lab	Total Pounds of HCOC per Lab
1994	228	85	72	32%	24	207
1995	224	121	112	50%	32	276
1998	244	109	101	41%	25	175
1999	235	97	88	37%	25	207

[9] Data was available for 1993, but the data collection method was significantly changed in 1994.
[10] Data for missing years is not available due to changes in the computer software used.

Year[10]	Forms Distributed	Rooms Reporting	Lab Supervisors Reporting	Supervisor Response Rate	Chemical Count per Lab	Total Pounds of HCOC per Lab
2001[11]	453	220	Unknown	49%	16	134
2002	220	205	160	73%	19	153
1995-1999 average	234	103	NA	40%	26	216
2001-2002 average	337	213	NA	61%	18	143
% change	44%	107%	NA	53%	-31%	-34%

One possible approach to improving laboratory response to the HCOC survey is through the implementation of a web-based version of the HCOC survey form to facilitate data input by laboratories and to improve the survey response rate. The EMP forms will also be distributed separately to increase emphasis on the HCOC surveys and inventories. In addition, ESF plans to use the ESF Compliance Audits to measure progress in removing outdated HCOCs from laboratory shelves. This will be done by making special note on the audit forms of any laboratories that have outdated time sensitive chemicals in storage. Using this system, ESF believes that it will be able to track the number of laboratories with this problem using 2002 as a baseline. ESF's goal for the 2003 survey is to increase the response rate to 85 percent, in order to continue to move the project goal of 100 percent participation. ESF plans to accomplish this by increasing follow-up with laboratory supervisors.

Findings: Disposing of outdated chemicals of concern is a top health and safety priority in the laboratory setting. Increased new domestic security issues around terrorism have heightened the awareness of colleges and universities to determine what hazardous materials are present on their campuses and develop proper housekeeping and management strategies to deal with chemicals both used and stored. The EMP establishes a good foundation for future improvements in this area. The three universities are working to ascertain a baseline or an inventory of outdated chemicals. It is apparent that laboratory moves and relocations have made this process lengthier and greatly increased the need for EHS presence in the laboratories to assist in the clean-outs. During the group discussions, laboratory staff and faculty at all schools universally expressed that because of the EMP and training, staff knew who to call in EHS and when to call them as it related to chemical clean-outs. Another result of the clean-out process under the EMPs is that it made laboratory staff and PIs more aware of what outdated chemicals were being held by individuals and thereby aided in the removal of unwanted chemicals. One PI at Boston College noted that only at the time of the clean-out was he made aware of the large quantities of chemicals that had been kept for a long period of time and were no longer needed in the laboratory. As a result, he was able to find another department to use the chemicals that were still in good condition (see EPI #4 on re-use).

Disposing of outdated chemicals seems to be a slow moving effort (partly due to the size of some of the relocation efforts involved at Boston College and UVM) and baseline values for this EPI have yet to be finalized. A lack of baseline values makes it difficult to measure progress in meeting this EPI.

The problem with measuring EPI #1 is that it is difficult to define what outdated means in the laboratory setting unless the chemical is determined to be a waste. According to the FPA, the EPI for HCOC chemicals is based on an "institution defined shelf-life." The schools have not been able to define what shelf-life means

[11] ESF changed data collection procedures for 2001.

at each respective school—if a PI chooses not to use a chemical for 10 to 12 years, should the chemical be considered a waste? A universal problem also seems to be that certain PIs and researchers will not dispose of chemicals for any reason—making it difficult for EHS to get an accurate assessment of how well this EPI is being met. Additionally, older chemicals tend not to have expiration and "best-used-by" dates on the bottles. On the other hand, some researchers find uses for chemicals beyond their expiration dates. Therefore, the biggest challenge for EHS staff with this EPI is to define shelf-lives for chemicals and then to push faculty and PIs to remove larger quantities of unwanted chemicals over time so that EHS can aid the laboratory in chemical reuse. Clarifying definitions will help to define expectations.

The universities have obviously invested time and energy into setting up a system for inventorying HCOCs in laboratories, per EPI #2. As of 2002, these systems are either on the verge of full-scale implementation (i.e., UMB's bar-coding system) or are up and running (i.e. UVM's inventory process as part of EPCRA). Again, according to the baseline audits, HCOCs were an area that all three schools needed to pay more attention to. Across all the schools the HCOC approach is under refinement and this can be viewed as an important benefit. At Boston College and UMB, the Boston Fire Department is an important stakeholder in determining whether the HCOC approach adopted at either institution is effective or acceptable and both have been readjusting their approaches to accommodate the Fire Department. At UVM, the HCOC survey process in 2001 was disappointing to ESF staff. However with the planned changes of a web-based form and better timing for form distribution, UVM should expect better HCOC return rates.

The EMP is designed to be flexible and responsive to change, and HCOC survey process should be similarly adaptive. All the schools responded well to some disappointments and shortcomings in creating a baseline system and are attempting to collect results by tweaking their original plans and schemes. Hopefully these interim changes will continue to produce results over the remainder of the project and will allow for continual process improvements to be made over time.

Recommendations: It would help if the universities established a baseline value for their outdated chemicals of concern so that there is some way to measure improvement, which can give EHS better leverage to urge faculty and staff to adhere to the EPI. The participants have formulated their surveys to meet multiple needs, local emergency response regulations and federal reporting requirements. They should make clear what works as a most efficient system to define what outdated generally entails for laboratory staff. Given that there may be some cultural barriers and it may not best to strive for removal of 100 percent of outdated chemicals from laboratory shelves, there is some middle ground from which to measure future progress. EHS can set a best-estimate baseline for clean-outs that occurred in the last two years based on chemicals removed. Therefore, if certain laboratories have recently conducted clean-outs, EHS can track those laboratories over the remainder of the project to make sure that no additional outdated chemicals remain in those laboratories. EHS can track which chemicals are being stored and for what purposes in those laboratories that consistently hold on to outdated chemicals. Although this may be time consuming and may not change the behavior of already intransigent faculty or staff, EHS can provide laboratories with recommended holding times for certain types of chemicals. There is a financial cost to excessive chemical hoarding as evidenced by UVM paying more than $25,000 to a contractor in 2001 to dispose of unwanted chemicals from the Chemistry Department stockrooms. EHS can try to use examples like this to increase Administration support to generate a change in behavior.

Reduction in source chemicals will help prevent having outdated chemicals remain on the shelves. The ChemSource (discussed in EPI #4) program initiated at UVM before EMP implementation is a good way to promote efficient chemical purchasing by the laboratories and prevents unnecessary stockpiling of large quantities of chemicals within the laboratories. Boston College and UMB should investigate initiating a similar program that would be tailored to the size and potential demand at each school.

Once baseline assessments are complete at Boston College and UMB, it may be easier for these two schools to have their HCOC inventory methodologies approved by the Boston Fire Department. In general, the schools should collaborate on methodologies for completing HCOC inventories. For example, after UVM tests the web-based form, and it is deemed effective, the other two schools may want to explore a similar approach and can perhaps adapt the form as necessary. As the schools are partners in this effort, sharing of information and resources, such as the web-based form can help overall project performance. In addition, the HCOC inventory has served another purpose in providing information to laboratories that are interested in chemical sharing. During the group discussion, one graduate student from Boston College noted that she was comfortable sharing chemicals from trusted laboratories and would walk down the hall and look up the HCOC inventories for the chemicals that she needed. Having the HCOC lists computerized (as at Boston College) or posted in a known accessible area to encourage this type of ad hoc chemical sharing should be encouraged.

With the EMP now fully implemented at all the schools and there is more familiarity with its purpose and general concepts (as evidenced through the group discussions), the schools should see greater response to the HCOC inventory process. EHS staff at all three schools can reach out more to their graduate students to be the champions of the HCOC inventory process. During the group discussion, a graduate student at Boston College stated that she thought that students would take more responsibility for proper laboratory management if they had a better understanding of the direct environmental, health and safety impacts of the requirements. Perhaps more emphasis during training needs to be placed the "why" aspect of the EMP, in particular to the HCOC process, in addition to the process of how to achieve compliance.

9.2 EPI #3 Goal: Pollution Prevention Assessments
Pollution Prevention Assessments.Completed (EPI #3). According to the FPA, the universities outlined the goal for this EPI as identifying <u>one P2 opportunity assessment per laboratory per year</u>. Some of the P2 projects, where indicated, are taken from the June 2001 and May 2002 Project XL Annual Report. Anecdotal evidence obtained through group discussions conducted in March 2002 indicate that the NEU Labs project has engendered renewed awareness in pollution prevention on the three campuses. However, the three schools have fallen short of satisfying this particular environmental performance indicator. Reasons for lack of P2 activity can be attributed to a variety of reasons discussed in the proceeding findings section. Suggestions for improving P2 are provided in the recommendations section.

Many of the P2 projects discussed below took place at the schools prior to EMP implementation. This EPI goal as stated might be missing much of the pollution prevention work that goes on at the university level for certain programs, by focusing on P2 on a project-by-project basis.

<u>Boston College:</u> Two committees collaborated in the spring of 2001 to develop a list of P2 activities in progress as well as those planned for 2001-2002 academic year. P2 opportunities explored in 2000-2001 were the collection and reuse of computers and electronic equipment, a mercury thermometer swap initiative and the recovery of silver wastes from photographic operations. The Committee was focused on the potential of silica gel recycling, the reuse/redistribution of laboratory waste and the mercury thermometer swap program. In April 2001, Boston College sold approximately 75 used computers. Also, EHS has been working with The Institution Recycling Network on developing markets for electronic equipment, including discarded laboratory equipment, either for resale or for components. These aforementioned P2 activities are ongoing.

Boston College has one silver recovery unit for the Photography Laboratories. Small photographic laboratories in the Biology Department have individual silver recovery units attached to the plumbing of the automatic photo-processors. When cartridges reach capacity, they are replaced and silver is extracted from the used cartridges and sold by the vendor. The units are renewed as necessary with the generation of approximately two pounds of silver.

Boston College worked with Triumverate Environmental to find a recycling source for silica gel. Plans were made to ship gel to SiliCycle, Inc., in Canada. However, the paperwork requirements involved in shipping wastes across the border caused serious delays in this transaction. Boston College has yet to find another recycling source for silica gel. Boston College generates approximately 1,000 pounds of silica gel per year.

The proposed activities for the 2001-2002 academic year were designated as follows:

- Complete the administrative process for recycling of silica gel by September 2001.
    - *Progress:* Cancelled
- Promote replacement of mercury thermometers in laboratories through training, email, the EHS web site, and personal communications.

    - *Progress:* Ongoing
- Investigate less toxic glassware cleaning alternatives to propose to users of chromic acid and nitric acid.
    - *Progress:* Ongoing
- Analyze solvent generation; promote collection of certain organic solvents (e.g. acetone) as a "pure" waste stream, which can be distilled and recycled. EHS will contact CBG Biotech, a company that sells solvent to recyclers.
    - *Progress:* As of March 2002, Boston College was beginning to investigate possible opportunities to reduce and reuse acetone wastes. It was determined that CBG Biotech would not meet Boston College's needs. Acetone is used in chemistry laboratories to clean equipment and represents approximately 40 percent of all solvent wastes generated on campus. During the on-campus group discussions, students and faculty noted that changes in lab practices could reduce acetone usage and better segregation of acetone may yield recycling opportunities.

Boston College will be working on two additional initiatives for 2002-2003:

- Continuing discussions with waste vendors to search for an outlet for recycling acetone (one of the largest wastes by volume) and other solvents at the quantity levels generated by universities; and
- Hosting with EPA, C^2E^2 and other participants, a workshop in Fall 2002 to discuss development of P2 strategies for the type of research being done at Boston College.

EHS can report the following successes based on its efforts to date:

- Waste volume from the chemistry teaching laboratories has decreased by 67 percent due to the use of microscale chemistry procedures.
- EHS continues to educate laboratories about alternatives to chromic acid cleaning solutions and has found that another laboratory is using a safer alternative.
- EHS has partnered with the Bakery Department (part of the Boston College Dining Services) to provide empty HDPE (high density polyethylene) containers to use as secondary containment in the laboratories.

<u>University of Massachusetts-Boston:</u> The focus for EHS and the Chemical Hygiene Committee is to place emphasis on pollution prevention through training. During training, emphasis is placed on pollution prevention and researchers are encouraged to incorporate product substitution, limited purchasing and other waste minimization strategies into their experimental design. In addition, EHS stresses the importance of purchasing only those chemicals that are needed and determining whether a treatment method can be incorporated as the final step in an experiment.

As of June 2001, the Chemical Hygiene Committee was developing a campus-wide program to replace mercury thermometers and a registration process for any remaining mercury containing devices on campus. As of June 2001, all six departments with mercury containing thermometer have replaced the mercury-containing thermometers. The Chemical Hygiene Committee is documenting the replacement activities and insuring that all mercury thermometers are replaced. In those instances where replacement is not possible, or the device is not a thermometer, the mercury containing device and its location will be registered with the Committee and the information maintained in a database.

UMB also has a Ph. D. program in Green Chemistry, which works to develop more environmentally benign chemical processes and products with in-depth knowledge of industrial operations and natural systems. A new Green Chemistry Laboratory for Research and Education in Sustainable Innovation is also in operation. This laboratory receives grants from private industrial organizations to find new alternatives for industrial processes. Opportunities to use Green Chemistry in laboratory methodologies and operations are currently being explored.

As of 2001, a new campus sub-committee was formed tasked with "greening research." This sub-committee is part of a larger campus-wide Sustainability Committee. The sub-committee will be examining pollution prevention opportunities in the research community on campus. Additionally, the committee will use the results of the P2 surveys (survey attached in Appendix 4) and encourage PIs to explore new P2 ideas to investigate. Approximately 65 PIs received the P2 surveys. As of March 2002, EHS received 27 completed surveys back (approximately 40 percent return rate). The results of the survey are presented in Appendix 4. In general, the results indicate that the majority of PIs have not heard of any P2 opportunities that they require assistance in investigating or pursuing, and that the majority of them are not seeking assistance or resources to help reduce laboratory wastes.

University of Vermont: Before the EMP was implemented at UVM, ESF focused its efforts on three areas: (1) Photographic Chemical Initiative, (2) Chemicals in the Art Department, and (3) Mercury Thermometer Swap.

(1)ESF has been working with staff responsible for photographic darkrooms in an effort to reduce the hazardous waste generated as spent photochemicals.

In this ongoing program, the option selected for each darkroom depends on specifics of that darkroom's operation. ESF personnel offer assistance, as needed, with these efforts including educating users and collecting samples for analysis.

(2) Chemical wastes from Art Department studios are managed under UVM's EMP and therefore the benefits of previous P2 successes continue to be felt under the EMP.

(3) In 1997, UVM instituted a voluntary mercury thermometer replacement program. ESF staff swap environmentally friendly thermometers for the mercury thermometers at no cost to university staff and faculty. In November 2000, UVM was recognized for this program and was awarded the "Governor's Award for Environmental Excellence in Pollution Prevention."

P2 opportunities that have been addressed post-EMP implementation include the following:

(1) Replacement of formaldehyde-based preservative for tissue samples with preservative solutions containing much lower concentrations of formaldehyde. The alternative solution was developed by the UVM gross anatomy teaching laboratories in order to reduce formaldehyde exposures to students in the 1970s. A newly identified use is for historical samples in the Pathology Department that are retained for long periods of time, and whose preservative solutions must be changed regularly. The old solutions are hazardous waste due to formaldehyde content. The alternative solution has a much lower level of formalin in it. This P2 approach has potential application in a wide variety of medical laboratories that use similar preservative solutions.
(2) The chemistry department is assessing several introductory chemistry laboratory exercises to determine whether they can be redesigned to achieve a goal of "zero waste." Specific chemicals are being considered for replacement. If this effort is successful, similar methods can be used to assess other experiments in the Chemistry Department, and potentially other departments as well.
(3) The Agricultural Testing Laboratory produces significant amounts of corrosive wastes in the course of their analytical testing. Members of the ESF staff are meeting with laboratory management to determine whether process changes to reduce these amounts are feasible.

ESF staff through informal contacts with laboratory workers identified the P2 exercises described above. In order to more systematically identify P2 opportunities in the laboratories, the ESF laboratory audits will include a P2 questionnaire in 2002. This questionnaire (presented in Appendix 5) will provide the data necessary to identify which P2 opportunities provide the most potential for effective hazardous waste minimization.

Other potential P2 opportunities for 2002 may arise from UVM's Green Chemistry projects. The professor in charge of these projects is taking a novel approach to creating direct laboratory applications of green chemistry principles. The professor is working with a student environmental group and chemistry students to redesign introductory Chemistry courses to make laboratory activities more environmentally benign. This idea has shown some success and more activities are expected in the 2002-2003 academic year.

ESF's goal for this EPI for 2002 is that 60 percent of the UVM laboratories (counted on a supervisor basis) return the P2 questionnaires. Future year goals will be to increase this participation rate until 100 percent of the laboratory supervisors have returned the survey form by the end of the project. To encourage participation, the 2002 ESF laboratory compliance audit form will specifically give credit to those laboratories that participate in this program.

Findings: Although the P2 EPI goal reads as following, "complete one P2 assessment per laboratory per year," this wording suffers from confusion over what defines a 'laboratory'. Many of the discussions during the proposal phase of this project defined 'laboratory' as all the rooms under a single PI. If the goal is restated in these terms, it is slightly more achievable for the schools. However, much work needs to be done in this area across all three schools. This is a very difficult EPI for all schools, as P2 is not factored into research, with the exceptions of the Green Chemistry activities at UVM and program at UMB. Yet, this is the area where the schools will make the most environmental gains to attain superior environmental performance, a requirement for Project XL. The P2 activities documented at the schools were activities that should be considered to be baseline—they existed or were implemented prior to the EMP. Therefore, now that the EMP is fully implemented, the universities must concentrate on generating new P2 opportunities and engaging the right individuals in P2 studies. Pollution prevention success will most likely result when there are champions of P2 approaches and there is increased environmental awareness on the part of laboratory workers—students, faculty and staff. The group discussion participants at all the schools indicated that the champions exist and that environmental awareness was more heightened with EMP implementation. The setting is opportune then for P2 assessments to emerge. Because this project is still in its early stages, it is useful to consider how P2 efforts are likely to evolve in the remaining years of the project. The discussion below reviews cultural changes that may enhance P2, systems that the schools have for promoting P2, and emerging P2 opportunities.

First, project participants note how the primary influence of the project on P2 may be a subtle and gradual cultural shift. On-campus discussion participants frequently noted how the project has made interactions between researchers and EHS more supportive and collaborative. Likewise, the process of developing and implementing the EMPs has raised the waste management knowledge and awareness of lab users. These changes may dovetail with pre-existing pollution prevention efforts (such as those in the Green Chemistry department at UMB and Green Chemistry projects at UVM) to produce P2 innovation. For example, a faculty member at UVM indicated that this project would help share waste management information among the whole lab community on campus, possibly allowing departments such as green chemistry to redirect their research in response to the most significant waste management problems. Similarly, Boston College laboratory users note that creation of chemical inventory sheets (a product of the NEU Labs project) has facilitated informal chemical sharing between labs in close proximity to one another.

While no formal P2 incentive programs currently exist at the participating schools, as mentioned above in the results section, each school is developing and implementing procedures for soliciting P2 ideas from lab users in the future:

- Boston College plans to integrate P2 into its hazardous materials and environmental awareness training. The trainers will use the training sessions to highlight the importance of P2 and encourage researchers to come forward with P2 suggestions.
- At UMB, EHS staff will be implementing a survey of faculty and students to identify potential P2 opportunities. For instance, this survey will explore whether lab users are receptive to reusing chemical bottles that have already been opened.
- UVM is promoting P2 through the school's green chemistry projects. For instance, one initiative will seek to redesign the introductory chemistry curriculum to encourage P2 and gather specific P2 suggestions.
- The threes schools, EPA, and C^2E^2, will be hosting a workshop in Fall 2002 to discuss development of P2 strategies at colleges and universities.

In general, the data and the discussion notes suggest that the participating schools are in the early stages of implementing P2 in response to the regulatory changes introduced under the NEU Labs project. To characterize their progress, it is useful to think of P2 efforts along three basic “tiers”, as suggested by an EHS staff member at Boston College:

- **Tier 1**: Easily implemented, small scale, product-specific waste reduction measures such as elimination of mercury thermometers.

- **Tier 2**: Reuse and recycling of significant chemicals and waste streams.

- **Tier 3**: More fundamental source reduction achieved through changes in research methods and lab practices (e.g., substitution of a less toxic chemical for a more toxic one already in use).

In the broadest terms, schools have made progress on Tier 1 (prior to the XL project) and have begun making progress on Tier 2; at least some of this progress is attributable to the NEU Labs project. However, the most significant P2 opportunities lie in Tier 3 and have not yet been fully explored.

A recurring theme in the discussions was how institutional factors can impede P2 innovations; especially design/research changes that yield reduced chemical usage, substitution of less harmful chemicals, or other source reduction. While EHS actively pursues waste minimization, most of their influence is limited to Tiers 1 and 2 described above and their focus is on management of waste once it is generated. In contrast, Tier 3 source reduction opportunities can be achieved only with input and support from researchers, especially principal investigators in charge of research plans. Faculty, particularly individuals at Boston College, noted the absence of a clear incentive system that would fuel academic interest in P2 innovation. While quality research is typically rewarded with publishing opportunities and other forms of professional advancement, the relevant academic disciplines do not offer such incentives for laboratory-level P2 research[12].

Practical constraints associated with laboratory settings may also limit design-stage source reduction. First, discussion participants noted how a researcher who has successfully implemented an experiment would be hesitant to change the approach in the interest of exploring P2 possibilities. Second, it may be difficult to identify widely applicable P2 measures because laboratories vary greatly in terms of the chemicals used and the wastes generated. In general, there are no large batch processes that generate standard waste streams, as found in industrial operations. Similarly, research technology develops rapidly, making it difficult for P2 innovation to keep pace.

The awareness created by the NEU Labs project has combined with pre-existing incentives (e.g., cost saving, risk reduction) to generate new P2 plans at the schools. Participants called attention to emerging P2 opportunities during the on-campus discussion. At Boston College, discussion participants highlighted reduction of acetone wastes as a potential P2 opportunity. Acetone is used extensively in chemistry labs to clean equipment and represents roughly 40 percent of all waste solvents generated. Participants, particularly the graduate students present, noted that changes in lab practices could reduce acetone usage and better segregation of acetone may yield recycling opportunities. At UVM, researchers have developed a non-toxic substitute for formaldehyde, a chemical used extensively in the medical school labs. These kinds of innovations suggest the schools may be integrating P2 more explicitly into research protocols and lab practices.

Overall, the NEU Labs project appears to have laid the foundation for P2 innovations at the participating schools, although only limited P2 progress has been realized to date. It is difficult to provide systematic suggestions for improving P2 performance, since this is a technical subject that is heavily dependent on the research program and other institutional factors at each individual school. However, based on the information discussed above, and on other observations offered in the on-campus discussions, the broad recommendations in the following section may warrant examination.

Recommendations: First, the participating schools should continue finding ways to improve communication between EHS and the lab users as a means of promoting P2. In general, EHS staff should send the message

[12] The field of green chemistry may represent an exception. This impediment to P2 may be more relevant at BC, where no formal green chemistry program exists, than at UMB and UVM where such programs do exist.

to faculty and students that P2 is an important aspect of complying with the school's EMP. The schools may benefit from considering each other's P2 promotion strategies. These include surveying lab users on potential P2 opportunities (as at UMB); featuring P2 in the training offered to lab users (as at Boston College); and working through green chemistry projects to redesign curricula to incorporate P2 (as at UVM). Second, communication with the students and staff conducting the research is imperative—the group discussions suggest that a whole group interested in P2 may exist, however individuals do not have the opportunity to meet regularly and share ideas.

At a more general level, EHS and lab users should work together to identify opportunities to share knowledge and promote university-level P2 in the academic community. The project participants could use forums such as the 2001 Green Chemistry Research Symposium (held at University of Massachusetts-Amherst) to gather ideas for P2 measures applicable at the NEU Labs schools and to promote the project with researchers at other schools. As noted above, the participants are hosting a workshop in November 2002 to discuss the development of P2 strategies. This kind of interaction may help publicize the need for waste minimization in university laboratories and gather suggestions from researchers working outside of the three participating schools. It might also help make in-lab P2 research a more visible field; while most green chemistry research currently focuses on refinement of industrial and commercial processes, many of the scientific principles may be equally applicable in a research laboratory setting. UMB and UVM can collaborate on the Green Chemistry activities taking place on their respective campuses. The professors engaged in these activities are already champions of P2 and would most likely be the most open to working together to further the goals of this project. For example, UVM's Green Chemistry professor is engaging a student group to develop a Green Chemistry approach to basic chemistry classes. A similar approach can be tested at UMB as well.

As an administrative action—it may be best to restate this EPI as the universities intended it and not leave it as it currently exists as stated in the FPA. In a regulatory experiment such as this project, all parties should endeavor to clarify goals and expectations so that the results clearly reflect the best efforts to attain those goals. The universities are leaving themselves open to questions as to why they are falling so short of a stated goal, when in fact the stated goal is not what they set out to accomplish.

Finally, EPA can help promote P2 among the NEU Labs schools (and elsewhere) by taking on a technical assistance and facilitation role. Options include the following:

- Consistent with preliminary ideas offered during the Boston College group discussion, EPA could sponsor and facilitate a workshop with chemical vendors, equipment manufacturers, and researchers to examine waste minimization opportunities. This idea would seek to implement P2 further up the supply chain for universities. In November 2002, EPA is sponsoring with Boston College a Pollution Prevention Conference.

- EPA could explore a variety of incentive mechanisms for encouraging lab-level P2 among the XL participants (or on a wider scale). For instance, the agency could offer a competitive grant, soliciting proposals for P2 from the participating schools. The award criteria could favor P2 measures that address especially large or toxic waste streams, and measures that are widely applicable at university labs across the country. To enhance the incentive, EPA could coordinate with professional journals to plan for publication of an article on the winning P2 innovation.

- EPA could assist the interested schools with an application for a Green Chemistry research grant and encourage the schools to apply for funding with other grants and scholarships offered through organizations such as the National Environmental Technology Institute, The Green Chemistry Institute, and the Center for Process Analytic Chemistry. More information about these and other organizations can be obtained at http://www.epa.gov/greenchemistry/grants.htm.

- EPA could assist with a pilot of the Chemical Management Program being run and coordinated by EPA's Office of Solid Waste. This program is designed to do centralized chemical purchasing with an eye on tracking chemical movements to highlight areas for reuse and reduction. The idea would be to work with a consortium of colleges to have a more robust program, given that schools' chemical waste streams are small and not concentrated. This program would require an investment of financial resources in order to help implement the program.

9.3 EPI #4 Goal: Increase chemical reuse/redistribution by 20 percent from baseline, EPI #5 Goal: Reduce hazardous waste generation by 10 percent

Amount reused or redistributed within the institution (normalized and compared with and without RCRA in the lab) and cost savings (EPI #4). The assumption behind EPI #4 is that relieving laboratories of the requirement for making a RCRA hazardous waste determination will remove certain laboratory chemicals from the waste stream and result in more redistribution and reuse of laboratory chemicals on campus. This EPI is therefore tied to total laboratory wastes per institution and cost savings (EPI #5), to reduce hazardous waste. The goal of a 20 percent increase (over baseline values) in reuse/redistribution of hazardous chemicals collected from laboratories over the life of the project, would help to meet the goal of a reduction in waste disposal of 10 percent (from baseline values) (see Table 4). These goals were expected to result from better management and more time availability to devote to chemical reuse and recycling under the EMP. The only existing data on chemical reuse in an academic setting is derived from the Campus Safety, Health and Environmental Management Association figure that approximately only 1 percent of chemicals are re-used or recycled. Therefore, these goals were meant to be far-reaching. The baseline data was derived from numbers generated in conformance with RCRA reporting requirements.

Although laboratory waste reduction is a meritorious goal for the universities, each school has encountered practical constraints with achieving this EPI. It is worth stating that the universities have made good faith efforts in trying to reduce laboratory wastes. The reasons that have made this goal unattainable for the universities are noted in the findings section.

Table 4: Reduction of Annual Generation of Laboratory Wastes[13]

	Boston College	UMass - Boston	UVM
Baseline (1999)	25,269 pounds	5,585 pounds	38,646 pounds
Goal	22,742 pounds (-10%)	5,027 pounds (-10%)	32,549 pounds (-10%)
2000 Data (Percent change from baseline)	36,674 pounds (+45%)	3,711 pounds (-34%)	38,269 pounds (+6%)
2001 Data (Percent change from 2000)	34,335 pounds (-7%)	5,585 pounds (+50%)-- no change from baseline	33,387 pounds (-13%)

<u>Boston College:</u> The Chemical Redistribution Program is explained in detail in the Standard Operating Procedure of the EMP. The Redistribution System began in March 2001 with an influx of chemicals from laboratories that were being relocated. During March 2001, EHS redistributed numerous cleaning supplies, four containers of lighter fluid, a Coleman fuel cylinder, a liter of hydrochloric acid, some salts, acids, bases and ethanol that will be used in EHS's waste identification program. In August 2001, Boston College distributed an electronic chemical inventory list to all laboratories, printed the list in the newsletter and posted it on the EHS website. EHS collected data on materials received and distributed.

Since the laboratory moves were completed in 2001, EHS notes that there have been no new chemical additions to the redistribution program. Virgin chemicals are not a regular part of the waste stream at Boston College. However, EHS has learned that chemical redistribution happens informally between laboratories in two ways:

[13] No workable method has been found to normalize these numbers.

(1) As graduate students, post-doctorate students and other laboratory workers leave the school; their chemicals are inherited by new workers who take over the projects or by other personnel in the laboratories, and therefore prevent orphaned chemicals.
(2) Laboratories conducting similar research and are typically located close to one another and will share chemicals across laboratories. Chemical sharing in this manner happens when the other laboratory is considered a "trusted source."

Compared to waste generation numbers for 1999, the amount of waste generated in 2001 by all laboratories increased by 55 percent. In-depth analysis of these data has shown that 80 percent of the laboratory waste at Boston College is generated by six laboratory groups, which comprise 15 percent of all laboratories. These laboratories are in the Organic Chemistry Division and one laboratory in Biochemistry. Since Boston College established the baseline, the Chemistry Department has received numerous research grants, especially in Organic Chemistry and Biochemistry, which enabled students and PIs to increase the research conducted. Naturally, waste increased by a very large amount. Furthermore, Boston College has stated as an academic mission that it will become a top research institution, and the Chemistry Department Master Plan includes the addition of five faculty members (and laboratories) to the department in the areas of Organic Chemistry and Biochemistry. Although Boston College is unable to meet the goal for waste minimization, EHS views the EMP as a valuable tool as it allows for better management of the volume of waste produced and better scrutiny of waste generation.

EHS has interviewed PIs and faculty to try and determine what options are available to address the waste volume problem. EHS is going to concentrate on the following issues to minimize waste generation:

- Implementation of a training program to better separate solvent wastes, in order to maximize the material going to fuel blending, and minimize the volume of material contaminated with halogenated compounds that goes straight to incineration.
- Purchase containers to assist in the solvent separation.
- Continue discussions with waste vendors to search for an outlet for recycling acetone and other solvents at the quantity levels generated by universities.
- Continue training focused on Pollution Prevention, and include the concept of Green Chemistry.

University of Massachusetts Boston: As determined from university manifests and the RCRA biennial report in 2000, the university generated approximately 3,711 pounds of hazardous waste generated in laboratories[14]. This decrease in hazardous waste generation was an 11.76 percent reduction in waste generation compared to 1999 (5,585 pounds). EHS attributed this reduction to smaller numbers of acutely hazardous wastes, organic peroxides, pyrophorics, flammable liquids and compressed gases. There were slight increases in overall amounts of corrosives, flammable solids and oxidizers. The EMP was implemented in October 2000; therefore it is not possible to link the reduction in chemical waste generation to the EMP.

In January 2001, EHS sent out a pamphlet to all principal investigators describing the purpose of a re-use and redistribution program. A formal reuse and redistribution was not in place prior to the XL project. The pamphlet also contained a tear-off sheet for PIs to fill out and return to EHS if they had any material available. EHS also introduced and promoted the program during training sessions.

In June 2001, EHS collected approximately 20 liters of materials. In May 2002 EHS completed an inventory list of excess chemicals. EHS published the list materials available for redistribution on its website (http://omega.cc.umb.edu/%7Eehs/labindex.htm) so that it is easily accessible once the hazardous waste accumulation area is completed by summer 2002. EHS notified all PIs about the list via email. When materials are identified as potentially reusable, they are labeled with the date. Each time the materials are used, they are tracked by EHS. If materials are in storage for more than two years, they will be disposed of. EHS obtains information concerning redistribution possibilities from direct mail, email, departmental

[14] RCRA requires a biennial report, which is submitted to the state every two years that details all waste quantities.
[15] As a result of small sample sizes, it is not possible to determine statistically whether the difference in responses between the two groups were significant.

postings, laboratory decommissioning and laboratory waste pickups. EHS expects to have use data of the excess chemicals in 2003.
University of Vermont: UVM's hazardous waste generation for 2000 was 38,269 pounds from research and teaching. UVM also has a Part B storage facility regulated under RCRA's Treatment, Disposal, and Facilities regulations, at which laboratory waste is sorted and repackaged for more economical disposal. The amount of waste shipped from campus has been fairly steady over time. Under pre-EMP conditions, the amount of hazardous waste disposed of in 2000 was 4 percent more than in 1999. This was well within the standard deviation around the average amount of laboratory waste generated during the 1990's (36,800 +/- 13 percent).

Table 4 for 2001 shows the laboratory waste generated by UVM laboratories, less the amount generated by the 2001 clean-out of the Chemistry and Agricultural Biochemistry Departments. The data demonstrates that laboratory waste generation dropped significantly in 2001, when chemical clean-out data is not included in the total laboratory waste generation value for UVM. ESF believes that the decrease in laboratory waste generation can be attributed to the ongoing presence of ESF staff in laboratories as they conduct laboratory audits and increased awareness of inventory management. These audits, which began in 1998 as "chemical storage surveys" generally, result in the disposal of chemicals that are recognized as surplus. ESF expects to see a continued decrease in the amount of waste generated. Other factors also affect the amount of laboratory chemical waste generated in 2002. A new medical research building was opened on campus, resulting in the movement of a significant number of laboratories between and within medical college buildings. These moves resulted in clean-outs of individual laboratories, which were processed, along with routine waste, at the Environmental Safety Facility. Similar clean-outs of campus laboratories occurred outside the medical college in preparation for the EPA/VT DEC audit. Most of these wastes are included in the amounts show in Table 4 (some of this waste was disposed of in 2002 and will be accounted for in the 2002 reported numbers).

ESF believes that based on current trends, it is possible for UVM to meet the goal for this EPI.

The baseline waste generation values are based on UVM's hazardous waste annual reports generated for VT DEC. Because UVM's Environmental Safety Facility is a Part B storage facility, UVM is required to file two reports—one for the waste streams generated on campus and another for those shipped out of the ESF. The numbers reported here are the amounts shipped from the campus to the facility. UVM used these numbers because at this point in the waste handling process, laboratory waste streams are easily differentiated from other campus waste streams.

The amount of hazardous waste shipped from UVM's laboratories (about 550) has been reasonably consistent from 1995-1999, with an average amount of just over 36,000 pounds during that period. It should be noted that the 1996 number does not include a large chemical clean out of the Chemistry Department that took place that year. This clean out produced more material than expected (about 11,000 pounds) and was not representative of a single year's waste production.

The annual variation from average of laboratory wastes (less than 10%) is much less than that observed for other campus wastes, whose totals are often driven by large construction and renovation projects which produce oil contaminated soils, lead paint debris, and other sporadic hazardous waste streams.

The most significant hurdle that ESF has found in instituting a laboratory waste reuse program has been that most laboratory workers are reluctant to use materials of uncertain quality. This trend is universal to all three institutions and is not unique to UVM alone. If researchers receive a chemical from a known, trusted source, he/she is more likely to use it. This process is not formal and therefore difficult to track or document. Most laboratory workers prefer to use chemicals directly purchased from chemical suppliers. Therefore, ESF combined its chemical recycling program with a chemical distribution program called ChemSource prior to the implementation of the XL program.

ChemSource, which has been operating for six years, involves ESF staff buying new chemicals in case lots and breaking down those case lots in individual containers so that laboratories can obtain necessary chemicals at a cheaper cost without purchasing them in excess. This aspect of ChemSource works in combination with the redistribution of chemicals discarded by laboratories. ESF measured the activity for this program from 1996 to 2000 (prior to EMP implementation). Based on the data collected (Table 5) ESF believes that strong patterns or trends for ChemSource use prior to XL had not yet developed. Table 6 shows the 1998 through 2001 results of the ChemSource program. This is expressed in the number of ChemSource orders delivered, because there is no common unit of measurement for the various chemicals delivered as part of this program. While the sale of new chemicals continues to grow as more laboratories participate in the program, the amount of recycled chemicals has not.

In 2001, ChemSource publicity efforts included representation at the UVM purchasing fair, at the scientific vendors fair, and the UVM Environmental Fair, a letter to the Chemistry Department in August and to chemical buyers in November, and joint projects with vendors to meet specific needs of chemical buyers on campus. ESF has established a goal for the ChemSource program and would like to see new chemical deliveries grow by 10 percent for 2002 and that the amount of reused chemicals delivered by the program increase by 50 percent. Progress towards these goals will be achieved by continuing outreach activities similar to those described above.

Table 5: UVM ChemSource Deliveries

Year	New Chemicals	Recycled Chemicals	Non-Mercury Thermometers
1998	363	5	11
1999	437	11	26
2000	440	11	18
2001	503	6	24

In 2002, ESF will focus on increasing both the amount of new chemicals and reusable chemicals redistributed. The expansion of the program will help minimize the amount of reusable chemicals generated by laboratories.

Findings: The universities have had and will continue to have a difficult time promoting, documenting, and achieving EPIs #4 and #5. The cultural barriers—voiced at all campuses visited—are a stumbling block to making official progress on these indicators. At all three universities, students and researcher faculty alike echoed the sentiment that chemical purity and quality assuredness is understandably of utmost priority for scientific research. Therefore, it is very unlikely for a researcher to use a previously opened or used chemical liquid, although he/she may consider using an opened chemical powder if the purity can be affirmed. Similarly, all stated that there was great hesitancy about re-using chemicals that had been taken by EHS. Although all the schools are beginning to institutionalize some formal chemical redistribution program—it does not seem likely that there will be a great deal of usage of these programs. What is promising, however, is that there are more informal chemical sharing opportunities that seem to be occurring between laboratories, and the participants should promote and capitalize on these opportunities.

The successful element of EPI #5 is that the schools generated baseline values of waste generation and they have been tracking their waste generation in comparison to the baseline. However, by looking at the waste generation numbers, it is clear to see there is fluctuation in the waste generation numbers and that it is difficult to characterize the average amount of waste generation for a lengthy period of time at each school. Although UMB was able to meet its reduction goals, all three schools have been struggling with the need to meet this EPI, for laboratories to conduct chemical clean-outs of outdated chemicals per EPI #1, and to complete laboratory clean-outs prior to laboratory relocations and moves. These are conflicting goals, as clean-outs and removal of outdated chemicals of concerns will increase waste generation. Another cultural barrier to achieving this EPI is that certain established research protocols require heavy chemical inputs—and there is currently no readily available alternative to researchers for certain protocols. Therefore, if an increase in research occurs, there will be a correspondent increase in research waste. Given the research culture and the need to do laboratory clean-outs, it is difficult to reconcile the need to meet the waste reduction goal in its current form.

Recommendations: EHS should promote informal chemical sharing opportunities by using the HCOC inventories. First, for example, if the HCOC is web-based or in an electronic database (currently being explored by UVM), EHS can match laboratories and send a notice alerting them to the fact that those similar chemicals are being used in a variety of laboratories. Again, the chemical sharing must occur with chemicals on shelves and not with chemicals tagged for EHS pickup. The easier the process is made for a researcher, the more likely he or she will make efforts to share chemicals. Second, more chemical sharing should be encouraged for student teaching. In basic science courses, laboratory curricula are defined well in advance that chemical sharing can be maximized. For these laboratory exercises, chemicals should first be pulled from the EHS cache of used chemicals before new chemicals are purchased, as the experimental purity is not of higher import than the learning process for the students. Third, chemical sharing may increase, where deemed appropriate by the researcher, as it is stressed in training.

The goal for EPI 5 as it stands does not meet the cultural research needs or the other EPI goals of this project. For the next two years of this project, it may be a better environmental goal for the schools to pursue a source reduction strategy. Given that there may be little room for improvement with more advanced research taking place at each university—EHS staff should focus on those processes where there is flexibility in research protocols. For example, a switch to microchemistry or green chemistry at each school in introductory Chemistry classes, might results in larger and more lasting environmental gains. Additionally, students in introductory classes will be taught about the benefits of these new approaches and will have an environmental awareness that they will carry with them throughout their academic experiences. Perhaps, if the goal of the EPI was to assess and implement at least one source reduction initiative, it is possible that the schools can see more lasting measurable effects of an EPI that is not affected by the clean-outs, is not research dependent, and raises the environmental awareness of its students.

9.4 EPI #6 Goal: Assess and demonstrate improvement in environmental awareness by using an environmental awareness survey

Survey Scores (EPI #6). **The purpose of the survey is to provide a standard by which to evaluate the success of hazardous materials and environmental awareness training. The survey also helps compare environmental awareness across campuses. The Environmental Awareness Survey developed for the project was a cooperative effort among the three universities. A survey specialist worked with the Environmental Health and Safety Offices at each of the universities to develop and finalize the survey instrument. The survey tests laboratory worker awareness in the following four major categories: (1) awareness of appropriate disposal regulations; (2) awareness of appropriate laboratory practices identified in each school's EMP; (3) awareness of the environmental impact of laboratories; and (4) awareness of the public health/safety impact of laboratories. The survey was administered in 2000 to obtain the baseline values and consisted of 16 questions total. The following table presents the questions asked on the survey broken down by the four categories. There are three different sets of survey results referenced below—(1) the baseline survey administered in 2000 before the implementation of the training program; (2) the first survey administered after the first year of training (referred to as the post-XL survey) in 2001; and (3) the 2002 survey. The original survey questionnaire is presented in Appendix 6**.

It is difficult to differentiate a pre-XL survey and a "post-XL survey" for this EPI as the three schools had training programs in place prior to the XL project and ongoing training while the EMP was implemented. In general, the data show that the post-XL training has enhanced environmental awareness at all three schools, although variable data collection and analysis methods should be taken into account when examining the results. Table 6 presents summary statistics on the population surveyed in both rounds, the number of participants representing relevant university populations, the survey delivery method, and response rates. Table 7 presents the baseline and post-XL survey scores for relevant questions. Again, based on the results, it is possible only to say that there appears to be a heightened environmental awareness on all three campuses as time elapsed between the first survey and the second survey. The survey distribution and target populations varied at each school. The variation in survey administration produced results from which we can only create a general picture of environmental awareness at each school and affects the way in which we analyze the comparative results of the environmental awareness survey. Because of the different test populations, it is not possible to attribute to the general environmental awareness improvement to the training.

In general, across the three universities in the post-XL survey, most laboratory workers did not have a good understanding of laboratory environmental impacts or pollution prevention concepts. However for the 2002 data, the surveys show that despite some improvements in these areas, the awareness of the surveyed population seems to have leveled off. Based on these results, the schools are faced with a number of the following challenges associated with both the training and the administration of the survey: (1) what is the best way to track and train undergraduate students and transient laboratory workers?; (2) should the physical impacts of laboratory activities be emphasized or can this information be distributed through alternative communication channels? (3) and what is the relationship between the survey scores and EMP compliance?

<u>Boston College:</u> The baseline survey was sent to all science faculty and a random selection of graduate students from lists supplied by the departments. The surveys were delivered to people through a combination of mailing and hand delivery, and respondents were asked to return the survey through the mail. A gift "give-away" raffle of a $50.00 gift certificate was provided to encourage participation and improve the response rate. However, EHS received complaints about not having the opportunity to win the raffle (since certain individuals did not receive the survey) so a second round of surveys were sent out. It is not known how many surveys were mailed in this second round. A graduate student also surveyed an undergraduate class of 25 students. Although 88 surveys were returned, a response rate was not estimated due to uncertainty about the total sample population that received the survey. EHS staff noted that because of the "give-away," some individuals who were not originally targeted for the survey obtained photocopies of the original survey and returned them to EHS.

The survey delivered post-XL training utilized a similar administration method to deliver 100 post-XL training surveys. All science faculty and a random selection of graduate students (chosen from lists supplied by the departments) received the survey. Again, EHS offered a $50 gift certificate as part of a raffle. Through a hand-count of returned surveys, approximately 19 surveys were returned through the mail, generating a response rate of 19 percent. The post-XL survey population was different than the baseline survey population, as the survey did not target solely those individuals who completed the baseline survey.

For the survey administered in 2002, EHS used a student worker to canvass laboratories and staff. The student went to each department and dropped off surveys with people he encountered, and later the same day went back collect the completed surveys. The student distributed 63 surveys over two days and collected 45 completed surveys for a return rate of 71 percent. As incentives for completing the survey, each person received a "BC Labs XL" pen, and names were collected for a $50 raffle. As an additional measure, the students handed out the survey answer key when people returned the survey. The student worker noted that in some laboratories, the surveys appeared to be group efforts and that access to certain labs was difficult due to locked laboratories and no staff present.

The survey in 2002 shows no great improvement in scores from those obtained in the post-XL training surveys. The 2002 survey population included six undergraduates, a group that does not receive training. The 2001 survey had a very small sample size and was completely voluntary, so the returns received may reflect better scores from a small population that has an unusually high interest in the EMP. For 2002, the survey was distributed to a larger group, including many people who may have not completed the survey if not personally approached. The change in methodology and sample sizes does not lend any meaningful comparisons or conclusions. EHS plans to use the survey distribution methodology used in 2002 so that the 2003 results will be more meaningful. Additionally, in the past correct answers to the survey were not distributed so participants were unable to know the correct answers and see where they made errors. The distribution of the correct survey answers in 2002 was received with interest and may have more educational value in the long run.

<u>University of Massachusetts at Boston:</u> An initial master list of all past individuals who had been trained by EH&S was used for the baseline survey. The list included a number of individuals who were no longer at the university. The survey was initially sent through the mail to 150 individuals who were asked to complete the survey and then send it back to the EHS office. After receiving a poor response rate, EHS sent an unknown

quantity of additional surveys to others on the list in order to encourage more participation. The response rate cannot be determined due to uncertainty about the total number of surveys administered through the mail, however 88 completed surveys were returned.

In 2001, UMB's training survey was randomly administered through the mail to 250 individuals—including those who had not received training. Approximately 54 individuals responded to the survey, generating a response rate of 21 percent. UMB conducted hand-counts of the second survey and summarized the findings on its website. As with Boston College, the post-XL survey population differed from the baseline survey population.

Approximately 60 people responded to the survey in 2002. EHS used the same survey distribution method as in the previous years. Although there is little change in the responses, there seems to be better responses related to the general environmental awareness questions. Correct answers on three questions—waste generation, fume hood emissions, and environmental impacts of laboratory work—rose 6 percent, 15 percent, and 10 percent respectively, from the 2001 scores. An interesting result of the survey in 2002 was that while the percentage of respondents trained in the EMP decreased by 20 percent, the percentage of those respondents who could identify the document governing the university's laboratory waste regulations increased by 3 percent. This may indicate that perhaps those who have been trained in the EMP may be more environmentally aware than those who have not.

University of Vermont: UVM's baseline survey relied on a directory of lab users (including faculty and staff) to randomly identify respondents, selecting a target sample of 100 individuals. ESF staff visited laboratories within the 21 academic departments and located the individuals or co-workers and asked them to participate. Individuals either (a) answered questions orally (i.e., in-person administration); (b) completed the survey on their own and returned it to the surveyors (i.e., self-administered); or (c) referred to the surveyor to a separate individual in charge of environmental safety for that lab. To encourage participation, ESF staff provided an incentive gift to all survey participants.

The first post-XL training survey was distributed using a similar master list of laboratory personnel. Again, 100 surveys were completed, both in-person and self-administered. UVM conducted hand-counts of the post-XL survey data and summarized the findings on the website. In addition, UVM entered the post-XL results into a Microsoft Excel spreadsheet along with the baseline results. This database was used to derive the individual results found in Table 8. The availability of data on the number of post-XL survey participants that had previously received XL training allowed for a supplemental analysis, presented in the "% Trained Respondents Only" column in Table. Figures in this column represent the percentage of correct responses for each question among those who received the post-XL training. Of the 100 post-XL training respondents at UVM, 86 had received training.

In 2002, UVM completed the post-XL survey for the second time. UVM used similar survey methods to the first time. In general, the responses show little change from 2001, although there is still significant improvement from the 2000 results. Improvement in 2002 was noticeable on specific questions, generally related to those about general environmental awareness. Correct answers on these (wastewater treatment, fume hood emissions, labeling requirements) increased between 3 to 5 percent. It is interesting to note that less than 50 percent of the population can recall the phrase "Environmental Management Plan" as the name for UVM's waste management program. This may indicate that retention of information is higher through hands-on applied procedures in the laboratory rather than through the distribution of information on the overall management structure and process.

Findings: In general, the data show that the post-XL training has enhanced environmental awareness at all three schools, although variable data collection and analysis methods should be considered when examining the results. Since survey distribution and analysis methodologies differed at each school the findings for this EPI are separated by school.

Boston College: The general upward trend in overall environmental awareness at Boston College laboratories is similar to the results found at the other universities. All key questions in each category of awareness demonstrate improvement over the baseline, despite a wide range of baseline understanding. For example, while nearly two-thirds of the respondents correctly identified EPA as the Federal agency that regulates the disposal of chemical wastes (Question #1), the post-XL training results indicate further improvement, as 88 percent correctly answered the question in 2001. Similarly, the baseline (Question #12), fewer than 10 percent of the respondents were unable to identify that the largest environmental impact of laboratory is high-energy use. Following XL training, the correct response rate increased to 25 percent. The Boston College results should be interpreted carefully, however, because Boston College's post-XL training survey includes only 16 respondents, which may not provide statistically significant findings.

University of Massachusetts Boston: The post-XL training results indicate noteworthy improvements at UMB as well. For example, while only seven percent of respondents could identify collection for hazardous waste disposal as the required disposal method for strong mineral acids (Question #6), nearly two-thirds of the respondents identified this answer following XL training. Likewise, less than a quarter of the respondents could initially identify the correct treatment method for laboratory wastewater (Question #9), but the majority selected the correct answer in 2001.

Consistent with the results of the survey analysis at the other universities, UMB respondents portray a poor baseline understanding of the environmental impacts of laboratories. For example, in both the baseline and post-XL training survey, approximately one out of eight respondents was able to identify energy use as the largest environmental impact (Question #12). One unpredictable survey result is the apparent decline in respondents' understanding of chemical waste treatment. The percent of respondents that correctly identified incineration as the most common chemical waste treatment dropped from 31 percent in the baseline to 17 percent following XL training (Question #2). There does not appear to be a clear explanation for this downward trend. IEc confirmed that approximately 31 percent of the respondents correctly identified incineration for Question #2 in the baseline, but could not confirm the apparent decline in understanding as indicated by the post-XL training results because the raw UMB survey data are not available.

University of Vermont: The availability of survey information in spreadsheet form provides an opportunity to conduct a more thorough and reliable analysis of the UVM awareness survey. The data generally show that the XL training yielded an increased understanding of the environmental and human health impacts of laboratories. The results for the post-XL population indicate that improved environmental awareness occurs across both the trained and untrained respondents. In other words, for the post-XL training survey results, the difference in correct responses between those that had received training that year and those that did not, were not significant[15]. One possible reason for this trend is that environmental awareness across the targeted population may have increased due to a general dispersion of knowledge from those who received training to those who did not. If this hypothesis is correct, EHS departments that face the logistical challenge of providing training to a laboratory population with a high turnover rate may still achieve the lasting benefits of improved environmental awareness.

Improved environmental awareness is demonstrated in two different ways. First, where the baseline survey indicates poor understanding prior to training, an improvement in awareness is evident. For example, the baseline survey indicates that less than one-third of respondents could identify the threshold amount of acutely hazardous waste that can legally accumulate in the laboratory (Question #7), but post-XL training results show that number nearly doubled. Second, where the laboratory population seems to exhibit significant prior knowledge (i.e., at least 50 percent of the baseline respondents could identify the correct answer), awareness also appears to improve. For example, more than two-thirds of the respondents already understood EPA's role in regulating hazardous waste (Question #1), but that awareness improved following XL training, with 84 percent of the respondents selecting the correct answer.

In other areas—particularly in the category that covers awareness of the environmental impact of laboratories—respondents still stand to make significant improvement over the course of the XL pilot. Approximately three-quarters of the respondents had trouble identifying incineration as the most common disposal method for laboratory hazardous material (Question #2); a similar number could not identify energy use as the largest environmental impact of laboratories (Question #12). While respondents demonstrated relative improvement on both of these questions following XL training, fewer than half could identify the correct response.

Recommendations: To improve the clarity and reliability of the findings, the participants should consider refinements to current survey administration and data management practices. First, to improve the effectiveness of the survey as a measurement tool, the schools may want to clarify the survey's intent. Given that the FPA does not dictate detailed objectives for the survey, participating schools should be sure to address this question. If the project managers feel that the survey is primarily a tool to assess overall environmental understanding among lab users, then the basic survey approach used thus far is generally adequate and can be refined through a variety of steps outlined in greater detail below. In contrast, if the survey specifically seeks to measure the effectiveness of XL training, then more fundamental changes to the survey instrument and survey method may be appropriate in future survey rounds. The discussion below provides a separate set of recommendations for this scenario.

If the intention of the survey is measure overall changes in environmental awareness, the following modifications should be initiated:

- For several reasons, Boston College and UMB should consider in-person administration of the survey (as done by UVM). Although this method requires additional time and resources, it is more likely to generate a large and statistically significant sample of respondents and therefore provide more robust environmental survey results[16]. The results would also be more robust because in-person administration would discourage collaboration on answers and therefore measure individual environmental awareness. To encourage participation, the schools may wish to offer material incentives to targeted respondents, but may want to avoid a "lottery" type giveaway that encourages unintended participation (as evidenced by what occurred at Boston College). UVM found that providing a small incentive to *all* participants was effective in encouraging survey participation.

- To ensure meaningful findings, the schools should distribute the survey more systematically across lab user sub-populations (e.g., workers, students, faculty, etc.). In-person administration will enable this kind of targeting because it avoids the response bias that can arise in voluntary mail surveys. For example, it would help avoid the problem Boston College encountered when surveys were duplicated and distributed to whole undergraduate classrooms. The resulting data will allow more reliable analysis of awareness changes among sub-populations and may provide findings useful for refining training or other environmental awareness enhancement actions.

- To facilitate future data analysis, schools should practice better data management. First, all hardcopies of the completed surveys should be stored carefully; loss of records from earlier survey rounds (as in the case of UMB) will undermine future analysis of awareness changes. Second, schools should enter baseline and subsequent survey responses into electronic databases (e.g., Microsoft Excel or Microsoft Access), as was done at UVM and Boston College. Appendix 7 presents a print out of Boston College's Excel spreadsheet containing post-training survey data, which can serve as a useful template for future survey data management.

- Schools should use the electronic databases to pursue more thorough analysis of the survey data. As noted, one area of interest might be analysis across different respondent attributes. Likewise, electronic data may allow more systematic analysis of open-ended survey questions[17]. For example, schools could analyze the frequency of terms or concepts provided in response to open-ended questions by electronically searching text fields in the database. As noted by the survey specialist that aided in developing the survey instrument, open-ended questions provide an effective way to measure respondent recall of certain issues (as opposed to multiple-choice, which tests recognition), and may also provide information on common misunderstandings among the laboratory population.

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[16] Note that in-person survey administration conducted at UVM proved feasible despite the large and dispersed campus; it is likely that a relatively smaller laboratory population at Boston College and UMB would facilitate future in-person administration.

[17] An open-ended question is one that does not provide the respondent with multiple choice options. Survey question #13 provides an example: "The last time you needed health and safety information about a particular chemical, what resource(s) did you use?"

As noted above, if schools determine that the primary intent of the survey is to measure the effectiveness of the XL training, additional survey changes may be appropriate. Most fundamentally, schools may want to consider administering a pre-training (i.e., baseline) survey as well as a post-training survey, rather than relying on existing data for baseline information. Although performing the full survey sequence would potentially demand significant resources, it would allow schools to pursue several refinements:

- First, new questions could be added to the survey. For example, if the training is modified, new questions could be added to track the effectiveness of new training elements. The sections of the survey that might be added would be useful for comparison to if previous survey baseline data, i.e., new questions will have no point of comparison in the old data.

- Second, the survey administration method could be changed to a panel design. In a panel survey, the same individuals would receive the survey before *and* after the XL training. This design allows more direct measurement of the training's effectiveness, at the group as well as individual level. While turnover in the lab-user population may present some challenges to this approach, it may be possible to administer the pre-training survey early in the school year and follow up with the post-training survey the following spring. Alternatively, the schools may choose to target graduate students because this subgroup is frequently in charge of day-to-day operations in the laboratory and generally remains in the lab-user population for longer periods of time (e.g., 2 to 6 years).

- If a panel design is too complex, schools could at least restrict the post-training surveys to lab personnel who have received the training[18]. Currently, schools survey the broader population of all lab users, including those who have and have not received training[19]. This will require that schools compile contact information for trainees; based on discussions with the university EHS representatives, schools have already begun collecting this type of information.

All of the recommendations discussed above can be summarized as a "protocol" for future survey rounds. Specifically, this evaluation suggests that schools adhere to the following practices:

- Administer the survey in-person rather than through the mail.
- Ensure that a minimum number of surveys (e.g., 100) are completed to allow meaningful and statistically significant data analysis.
- Ensure that respondents represent a cross-section of the target population. If general awareness is considered, respondents should include a proportional mix of lab users. If training effectiveness is considered, respondents should include trainees only.
- Retain and store hardcopies of all completed surveys.
- Enter all survey data into an electronic database format.
- Analyze all data thoroughly to address key questions.

Table 6: Summary Statistics of Survey Administration (baseline and Post-XL results for 2001 and 2002).

SUMMARY OF SURVEY ADMINISTRATION									
Survey Statistic	**Boston College**			**UMB**			**UVM**		
	Baseline	**Post-XL**	**2002**	**Baseline**	**Post-XL**	**2002**	**Baseline**	**Post-XL**	**2002**
Surveys administered	***unknown***	100	63	>150[a]	250	60	100	100	100
Surveys completed	88	16	45	87	54	60	100	100	100
Response rate	N/A[b]	16%	71%	N/A[c]	21%	100%	N/A[d]		
- Staff Admin.	2	-	7	5	1	1	4	2	1
- Staff- Lab Tech	1	1	8	9	9	11	56	42	59

[18] Note that schools may wish to include untrained individuals as a control group against which trainees can be compared. This is acceptable if an adequate sample size is achieved for both groups.
[19] For the existing post-training survey, only UVM tracked which survey respondents did and did not receive training.

Summary of Survey Administration									
Survey Statistic	**Boston College**			**UMB**			**UVM**		
	Baseline	**Post-XL**	**2002**	**Baseline**	**Post-XL**	**2002**	**Baseline**	**Post-XL**	**2002**
- Grad Student	3	9	30	12	16	24	23	38	26
- UG Student	67	0	8	39	12	14	7	9	3
- Faculty	15	6	4	19	15	10	9	9	11
- (Left blank)/NA	NA	NA	6	4	0	0	1	NA	NA
Survey delivery	Combination of mail & hand-delivered. 2002—Hand-delivery and pick-up of survey.			Mail until 2002, then hand-delivered			Hand delivered		
Survey administration	Self-administered			Combination of in-person & self-administered			Combination of in-person & self-administered		

[a] Results from BC's baseline survey are based on hand counts conducted at the school and IEc review of the hand count compilations. The post-XL training survey results are based on IEc review of electronic data provided by the school.
[b] Results from UMB are based on hand-counts conducted at the school and, except where indicated, have not been verified by IEc or EPA.
[c] Results from UVM are based on IEc analysis of hand-count data in electronic form provided by UVM.
[d] Note that BC's baseline survey results are presented on the New England Labs Project XL website as "number" of respondents, while the post-XL training results are presented as percentages. The data in this exhibit are only presented as percentages.
[e] Note that BC's post-XL training survey includes 16 respondents, which may not be statistically significant.
[f] "% Correct - Trained Respondents Only" represents the percentage of correct responses among those who received the post-XL training. Of the 100 post-XL training respondents, 86 received training. UVM was the only school for which data was available to calculate "Trained Respondents Only."
[g] Note that the percent of correct responses for question #5 refers to the number of respondents who correctly identified *source reduction* as the number one most preferred waste management strategy, but not necessarily the correct order for all four strategies. Raw data provided by BC allows for review of the data to ascertain the number of respondents that identified all four preferred waste management strategies in the correct hierarchy. For BC respondents, 38% (33 of 88) of the baseline survey respondents identified the preferred waste management hierarchy for pollution prevention; 63% (10 of 16) of the post-XL training respondents identified the same.
[h] This figure is based on hand-count of the original paper copies of the baseline surveys from UMB. 47 percent (41 of 87) identified source reduction as number one in the hierarchy of pollution prevention.
[i] At the time the baseline survey was administered, the Environmental Management Plans at each school had not been completed or publicized in the labs.

Table 7: Comparison Environmental Awareness Survey Results

COMPARISON OF ENVIRONMENTAL AWARENESS SURVEY RESULTS										
	Boston College[a]			University Massachusetts -Boston[b]			University of Vermont[c]			
Survey Question & *Correct Answer*	% Correct Responses Baseline[d]	% Correct Responses Post-XL[e]	2002 Post-XL	% Correct Responses Baseline	% Correct Responses Post-XL	2002 Post-XL	% Correct Responses Baseline	% Correct Responses Post-XL	% Correct - Trained Respondents Only[f]	2002 Post-XL
Awareness of appropriate disposal regulations										
Q1. Which Federal agency regulates the disposal of chemical wastes? (multiple choice) *Environmental Protection Agency*	60%	88%	74%	42%	81%	72%	69%	84%	86%	84%
Q7. What is the maximum amount of acutely hazardous laboratory waste that your laboratory is allowed to accumulate? (open-ended) *One quart or one liter*	26%	44%	15%	31%	42%	36%	30%	57%	52%	58%
Awareness of appropriate laboratory practices identified in each school's EMP										
Q5. In the book, "Prudent Practices in the Laboratory" what is the preferred waste management hierarchy for pollution prevention? Use a scale of 1-4 with 1 being the preferred management method.[g] (open ended) *Source Reduction* *Recycling/reuse* *Treatment* *Land disposal*	41%	81%	63%	47%[h]	70%	47%	52 %	67%	67%	73%
Q6. What is the proper way to dispose of strong mineral acids? (multiple choice) *Collection for Disposal as hazardous waste*	22%	57%	33%	7%	60%	53%	76%	82%	87%	74%

COMPARISON OF ENVIRONMENTAL AWARENESS SURVEY RESULTS

Survey Question & ***Correct Answer***	**Boston College[a]**			**University Massachusetts -Boston[b]**			**University of Vermont[c]**			
	% Correct Responses Baseline[d]	**% Correct Responses Post-XL[e]**	**2002 Post-XL**	**% Correct Responses Baseline**	**% Correct Responses Post-XL**	**2002 Post-XL**	**% Correct Responses Baseline**	**% Correct Responses Post-XL**	**% Correct - Trained Respondents Only[f]**	**2002 Post-XL**
Q14. What document describes how to dispose of laboratory hazardous waste at your institution? [i] (open-ended) *Environmental Management Plan*	0%	50%	13%	0%	51%	53%	0%	68%	69%	35%
Awareness of the environmental impact of laboratories										
Q2. Ultimately, most chemical waste generated in the laboratories are: (multiple choice for type of disposal) *Incinerated*	22%	50%	67%	31%	17%	23%	26 %	47%	50%	32%
Q9. How is wastewater from your laboratory buildings treated? (multiple choice) *Diluted with rest of the building's water, then goes to the sewer for municipal treatment by aerobic digestion*	38%	69%	54%	22%	56%	27%	72%	82%	81%	87%
Q12. Typically, what is the largest environmental impact of laboratory work? (multiple choice) *Energy use to cool or heat laboratory space*	8%	25%	15%	13%	14%	23%	20%	32%	34%	45%

COMPARISON OF ENVIRONMENTAL AWARENESS SURVEY RESULTS

Survey Question & ***Correct Answer***	**Boston College[a]**			**University Massachusetts -Boston[b]**			**University of Vermont[c]**			
	% Correct Responses Baseline[d]	**% Correct Responses Post-XL[e]**	**2002**	**% Correct Responses Baseline**	**% Correct Responses Post-XL**	**2002**	**% Correct Responses Baseline**	**% Correct Responses Post-XL**	**% Correct - Trained Respondents Only[f]**	**2002-Post XL**
Awareness of the public health/safety impact of laboratories										
Q10. In general, how are fume hood emissions controlled in your laboratory? (multiple choice) *Dilution with laboratory room air*	14%	19%	26%	21%	65%	35%	38%	51%	53%	55%

[a] Results from BC's baseline survey are based on hand counts conducted at the school and IEc review of the hand count compilations. The post-XL training survey results are based on IEc review of electronic data provided by the school.
[b] Results from UMB are based on hand-counts conducted at the school and, except where indicated, have not been verified by IEc or EPA.
[c] Results from UVM are based on IEc analysis of hand-count data in electronic form provided by UVM.
[d] Note that BC's baseline survey results are presented on the New England Labs Project XL website as "number" of respondents, while the post-XL training results are presented as percentages. The data in this exhibit are only presented as percentages.
[e] Note that BC's post-XL training survey includes 16 respondents, which may not be statistically significant.
[f] "% Correct - Trained Respondents Only" represents the percentage of correct responses among those who received the post-XL training. Of the 100 post-XL training respondents, 86 received training. UVM was the only school for which data was available to calculate "Trained Respondents Only."
[g] Note that the percent of correct responses for question #5 refers to the number of respondents who correctly identified *source reduction* as the number one most preferred waste management strategy, but not necessarily the correct order for all four strategies. Raw data provided by BC allows for review of the data to ascertain the number of respondents that identified all four preferred waste management strategies in the correct hierarchy. For BC respondents, 38% (33 of 88) of the baseline survey respondents identified the preferred waste management hierarchy for pollution prevention; 63% (10 of 16) of the post-XL training respondents identified the same.
[h] This figure is based on IEc hand-count of the original paper copies of the baseline surveys from UMB. 47 percent (41 of 87) identified source reduction as number one in the hierarchy of pollution prevention.
[i] At the time the baseline survey was administered, the Environmental Management Plans at each school had not been completed or publicized in the labs.

9.5 EPI #7 Goal: Increase the percentage of students and laboratory workers receiving training
Students in teaching laboratories and laboratory workers receiving training (EPI #7). The goal of the training EPI is to increase the number or percentage of students and lab workers receiving training. There was no baseline assessment for this EPI, however with the EMP implementation came a more institutionalized training system. Each EMP details the training methodologies employed. Training laboratory workers in laboratory safety, environmental management, and regulatory compliance issues is of foremost importance in creating and sustaining a laboratory management system under the EMP. In the college and university setting, tracking laboratory workers and then administering training is extremely difficult as laboratory workers, staff, researchers and students are extremely transient. Therefore over time, as the schools continue to build effective training infrastructure, the number of laboratory workers trained each year may begin to stabilize or decline, depending on whether refresher training is required by the institution or the department. Given this potential trend, it may be best that other indicators, such as EMP compliance results and the environmental awareness survey serve as good measures of progress in addition to gathering data on the numbers trained.

Boston College: Training is managed in the different departments with various degrees of systematization. The EHS office coordinates and/or provides training and maintains a central record of who has been trained. Every laboratory has an EHS Contact Person who has received training and is asked to give new laboratory workers information and specific on-site training prior to attending formal training. Due to the changing population in the laboratory, the department administrators manage the training lists. The EHS office provides a list of people trained and the administrator must crosscheck the lists of those working in the labs and those trained.

Some department administrators have established the following training policies for their laboratories:

- Geology and Geophysics—no individual is allowed in the chemical laboratories unless his/her name is posted on a list that states that they have completed the training requirement;
- Chemistry—mandatory training during orientation for new graduate students prior to the start of school in August. New post-docs and staff may also be trained at that time, or will attend training scheduled by EHS at other times. An annual refresher course is offered in June that includes EMP and CHP material and is attended by nearly everyone in the Chemistry Department; and
- Biology and Physics—the position of an Operations Manager has been added to these two departments and is following the training policy of the Chemistry department.

Based on the data, the majority of laboratory workers received EMP training. All laboratory workers in Psychology (three individuals) and nearly all Geology and Geophysics individuals were trained. During the academic year 2000-2001, the Chemistry Department had at least 95% compliance (approximately 160 individuals) with the training requirements. Training was very successful in this department due to a department administrator who actively pursues people who need to be trained. The Biology Department training was somewhat hindered by major renovations in the Biology Building. Training issues were addressed in the fall 2001 with the EHS Oversight Panel. EHS has the full support of academic deans to achieve the training goal of reaching all laboratory workers. The following table (Table 8) provides the number of individuals trained as compared to the estimated total number of laboratory workers per department.

Table 8: Boston College Training Data, 1999-2002

Department	# People who have received EMP training since implementation	Estimated # total laboratory workers in facilities
Biology	73	63
Chemistry	183	140
Geology	40	29
Physics	9	10
Psychology	3	3

University of Massachusetts Boston: In September 2000, EHS notified all relevant departments that training would begin the end of October 2000. Departments were asked to identify all individuals, particularly students, who needed training. Prior to formal training, EHS formulated and distributed summary pamphlets about Project XL and specifics about laboratory waste collection to members of each relevant department at the beginning of October 2000. Training in the new CH/EM plan for all faculty, staff, graduate students and undergraduates who work alone in laboratories began at the end of October 2000, and continued over the next several months. At that time, EHS also posted new signs in each lab consistent with the CH/EM plan and distributed new "tie-on" laboratory waste tags.

EHS maintains a constant list of all PIs (faculty and staff) who can be contacted directly when the need arises. The training program is a general introduction to the new regulations set forth in the CH/EM plan and is carried out predominantly on a lab-by-lab basis. Each trained lab worker receives a copy of the CH/EM plan. When feasible, EHS has trained groups from departments in a single session. Each session can last between 30 and 60 minutes long. The EHS goal was to have all laboratory personnel trained in the CH/EM plan by March 2001. As of June 2001, EHS had trained the Anthropology, Physics, and some of the Biology and Chemistry departments. In fall 2001, training was completed for the remaining members of the Biology and Chemistry departments and the Environmental, Coastal and Oceanic Studies program. EHS's plan to train all laboratory workers within twelve months of a training program rollout is an improvement over past training experiences, which required additional time.

EHS completed a more accurate training database. EHS sends out forms to the PIs asking them to identify all laboratory personnel under their supervision who require training. This information is then entered into the database and training information is generated on a semester-by-semester basis for the PI to update, thus ensuring that the training records are up-to-date. As of May 2002, EHS has trained 89 percent of those identified by the PIs as individuals covered by the CH/EM plan.

University of Vermont: The laboratory worker training process is a partnership between ESF staff and the laboratory supervisor. Between March 1 and June 28, 2001, ESF trained 529 laboratory workers. The relatively high level of participation resulted primarily from commitments by laboratory departments that their laboratory workers would attend these sessions, and vocal support from the Provost and Deans.

In the 2001-2002 academic year, UVM was in the process of implementing a personnel training documentation system tied to the Human Resources database. The database, driven by the regulatory requirements for health and safety training, makes it easier for both departments and ESF staff to track employees that are working in laboratories and the training that they are receiving. This system is expected to improve the participation rates in training efforts. As of the fall of 2002, the tracking system is still under development. ESF continues to work with the UVM Administrative Information group and the Human Resources Department on this effort.

Table 9 below shows the rate at which people are trained in chemical management and environmental awareness at UVM. Training numbers have doubled since the inception of the EMP. This increase does support the findings that general environmental awareness has improved and increased in the laboratories. ESF plans to keep stressing the main components of the EMP training that seem to be having a good impact on the trainees, while looking for new training techniques and topics to cover in order to improve overall environmental behavior, understanding and awareness in the laboratory.

Table 9: Environmental training for UVM Laboratory Workers

Year	Number of people receiving chemical safety/environmental awareness training
1998	140
1999	299
2000	284

2001	600
First quarter 2002	135

Findings: The schools have performed very well with this EPI. Across all the universities, EHS staff clearly articulated that training is a high priority and is therefore quite resource intensive—mainly from a human resource perspective. The tracking of exact numbers of those being trained is improving, and will most likely continue on this trend as more people are familiar with the EMP, EHS staff, and as the Administrators stress the importance of training to its faculty. In general, the schools on average are probably reaching approximately 80 percent of their targeted populations in training.

The academic laboratory population is extremely transient, which greatly hampers the ability of EHS to train 100 percent of the targeted population. A universal issue is that principal investigators have a fair amount of autonomy in hiring or having volunteer students work in laboratories. The most difficult populations to train are those students who are doing volunteer research or are visiting students, as there may not be any "paperwork" that would identify the student as a candidate for training. Additionally, PIs submit training lists to EHS, and therefore may not list all individuals who may be using the laboratory, depending on the discretion of the PI.

All three schools identified graduate students as the population that should be targeted in training, as they tend to stay longer in the laboratory and can serve as points of contact for those students and staff who are not trained. During the on-campus discussions, the graduate students were most often cited as the individuals who completed the laboratory self-inspections or served as the laboratory safety contact.

The group discussions highlighted an interesting aspect of training—those who are trained serve as informal on-the-spot trainers within the laboratory for individuals who have not been trained. The informal trainers tend to be graduate students and in many cases also are the students who serve as safety contacts or the individuals who fill out self-inspection forms. These are the linkages that EHS has with the laboratory and can more fully utilize as conduits of information and best practices within the laboratory. The Environmental Awareness Survey results suggest that a trickle down of knowledge is occurring in laboratories as scores for the survey increased the second time, even with the population that had never been trained. All discussion participants who had attended training articulated that the training was very helpful and the benefits of training were particularly obvious to the auditors during laboratory inspections. During group discussions participants expressed the following benefits of training:

- Increases awareness of what is required of individuals in the laboratory;
- Builds relationships with EHS staff—students, staff, and faculty know who to call with specific questions or problems;
- Stresses the importance of safety protocols and reinforces existing best practices within the laboratory.
- Introduces the EMP concept and its role in creating a better management system in the laboratory.

During the audit, both EPA and State representatives alike commented that it was encouraging that in the majority of laboratories inspected, the laboratory staff were very familiar with the EHS staff and in general had an understanding of what the XL project entailed. These factors can be attributed specifically to the training, and more generally to the implementation of the project.

Recommendations: First, EHS staff at the schools can consider "training the trainers" to capitalize on the informal on-the-spot training that is going on. Since these are often graduate students, they also serve as safety contacts and might benefit from training aimed at their status.

Second, in response to comments during campus discussions, is a recommendation to focus training on laboratory best management techniques for certain laboratory practices. For example, one to two graduate students noted that the training was quite general and did not focus on particular concerns in a given laboratory or specify good techniques for certain laboratory practices. The participants suggested that perhaps these aspects could be incorporated into the training. Although this may be a time investment by EHS, needs could be assessed during regularly scheduled audits and this specialized training could be offered once a year, given that the graduate students would be the target audience and that they tend to stay in the laboratories longer.

Finally, and perhaps most importantly, EHS staff should work with faculty and the Administration to create incentives for students who serve in these informal leadership positions (whether it be as informal trainers or as the safety contacts) in the laboratory. Many students are trying to build their research resumes and would therefore benefit from having an official title (i.e., Laboratory Safety Coordinator) and recognition for their work. Various incentives, such as a certificate of recognition presented by the university officials at a special event or a gift certificate in addition to an official titled position, were discussed during group discussions at UMB.

9.6 EPI# 8 Goal: Achievement of objectives and targets

Objectives and Targets (EPI #8). According to the FPA, this EPI is designed to measure the effectiveness of the universities' approach to measuring objectives and targets. Part of the objectives and targets are to establish baselines for future comparison and to look at results to date in comparison. Although the measurement of costs of compliance, including waste disposal is included as a baseline measure, it is not explicitly defined as part of an EPI. It was thought that perhaps waste disposal costs would be one indicator of EPI effectiveness. The table below (Table 10) presents baseline values on cost information collected from each school for the fiscal year 2000. The costs presented were the average per laboratory for 2000. UVM has the largest number of laboratories of the three schools. Based on the values and trends seen observed since the baseline figures, program effectiveness is not measured well through costs of laboratory wastes. Increases in research conducted or laboratory clean-outs directly influences the amount of waste needing disposal, which is appropriately reflected in the higher disposal costs for a school. The dollar values therefore do no correspond to how well the EMPs are working.

Table 10: Baseline Waste Disposal Costs for FY 2000

Costs of Laboratory Waste Management (FY 2000)		
	Total Cost	**Average Cost Per Laboratory**
Boston College	$122,612.00	$943.17
UMB	$27,991.00	$194.28
UVM	$258,960.00	$481.34

Findings: The other performance indicators define whether or not this EPI is met. It is clear that the universities have invested work into setting baselines and providing comparative results, however, there is room for improvement.

Recommendations: This EPI on its own does not truly indicate program effectiveness. However, it implies that the schools should be tracking the other EPIs in order to measure success. This EPI means more if it is stated as monitoring and reporting, with the goal being to track and report progress in a timely and consistent manner. That said, for the remainder of the project the schools should construct a set of consistent monitoring and reporting tools that would be reflected in subsequent annual reports by the XL schools. For example, the baseline information in the first annual report is not consistently presented in the reports for 2001 and 2002. For most EPIs this project defines progress in comparison to the baseline; therefore more efforts need to be made to describe baseline values. This is especially important for the environmental awareness survey. A history of results and documentation of how and why the EPI results are presented are necessary pieces of information in order for EPA and the States to evaluate overall program effectiveness and the potential for successful regulatory reform. In general, more efforts must be made to make annual reports consistent, and to document the status of efforts from one year to the next.

Additionally, the baseline measure for waste disposal costs is not a meaningful baseline measure over the course of the project. Waste disposal costs are a function of the amount and type of waste generated. However, the amount of wastes is not necessarily due to unnecessary production of waste because it can be greatly influenced by an increase in the amount of research (due to increases in grants received). The universities have attempted to find a methodology to normalize waste measures but because of the diversity of ever-changing nature of university research, nothing they have tried (such as attempting to normalize the number by laboratory size or research dollars) has proven to be consistently correlated with waste generation.

9.7 EPI #9 Goal: Report Improvement on EMP conformance

EPA's increased attention and focus on universities and colleges has highlighted certain areas in the regulations where academic institutions have difficulty staying in compliance with the regulations[20]. Prior to increased numbers of inspections of colleges and universities, in general, EPA inspectors did not have a good understanding of the nature of environmental management at these institutions. This universe was operating below the inspection radar screen for quite a while until the mid 1990's.

When EPA issued enforcement alerts for the college and university sector, EPA inspectors found a number of violations at academic research institutions of all sizes and types throughout the country. As a result of these findings, EPA increased its compliance assistance to bring about greater awareness of the policies and preventative actions that universities can take before enforcement actions become necessary. Enforcement efforts are also augmented to focus academic attention to the nature of environmental problems on campuses and try and bring more universities into compliance with the regulations.

As part of the evaluation, IEc and EPA New England reviewed compliance and inspection reports for universities that are not part of the XL program in order to have a more complete understanding of the nature of laboratory RCRA violations and to see if the NEU Labs universities are achieving this EPI comparatively well. Based on anecdotal evidence obtained through the group discussions, there is the feeling that compliance at the XL schools should be better (due to the EMP) than at the larger universe of colleges and universities. Group discussion participants at the three schools echoed similar themes of feeling more comfortable in the laboratory because every person now knows what he/she is responsible for to ensure compliance, there is heightened environmental awareness, and that individuals ask more questions and know where to find help with EHS issues. The expectation is that these sentiments translate into actions to promote and attain compliance in the laboratory.

EPA did not audited the three XL schools prior to the XL project, however UVM was audited by VT DEC. To help characterize the enforcement impacts of the NEU Labs project, IEc assisted EPA New England with a review of audits at non-XL university laboratories. Specifically, RCRA violations were examined from EPA-audited universities in EPA New England and Regions 2 and 9. Unfortunately, the inspections and audits reviewed included the entire RCRA program at each institution and usually included only a sampling of laboratories (with a greater focus on waste accumulation areas) whereas the NEU Labs project focuses solely on laboratories.

The following table (Table 9) summarizes the violations recorded in the audits at non-XL schools. The table shows the number of campuses that had at least one instance of the given violation. As shown, failure to make a waste determination, failure to properly label containers, and failure to train laboratory staff are the three most common violations. The most common violations found in this review match those general

[20] Roth, Alisa. *The EPA Versus the Toxic Campus.* University Business. (April 2000).

RCRA violations found in earlier guidance developed in outreach to universities. Therefore, these consistent sources of information are useful in describing the most common RCRA violations prior to the implementation of the NEU Labs XL project.

Table 11: RCRA Violations of 22 Non-XL Participating Universities

SUMMARY OF RCRA VIOLATIONS AT 22 UNIVERSITY CAMPUSES [a, b, c]

Violation	Number of Campuses with that Violation (%)
Failure to make **waste determination** [40CFR 262.11]	21 (95%)
Failure to **"label"** hazardous waste OR Failure to mark containers clearly w/ **words "Hazardous waste"** [40 CFR 262.34(a), 262.34 (c)(1)(ii), 262.34(d)(4) (rule interpretation different in MA)]	16 (73%)
Failure to ensure **hazardous waste training** to researchers and students who generate hazardous waste (both onsite and offsite, waste mgr haulers) [40CFR 262.34 (d)(5)(iii)]	14 (64%)
Failure to conduct **or document weekly inspections** [40CFR262.34(d)(2)].	12 (55%)
Failure to ensure **closure of hazardous containers** [40CFR 265.173(a), 262.34(d)(2)]	11 (50%)
Failure to **date accumulation** of waste, or otherwise track accumulation time [40CFR 262.34(a)(2), 262.34(d)(4)]	10 (45%)
Holding hazardous waste that is **incompatible** with other wastes [40CFR 262.34 (a) (1) (i), 262.34(d)(2)]	8 (36%)
Failure to develop adequate **contingency plan** [40CFR 262.34(a)(4)]	7 (32%)
Failure to **minimize potential for release** of hazardous waste to air, soil, surface water [40CFR 262.34(a)(4), 262.34 (d)(4), 265.31]	6 (27%)
Failure to provide telephone or other **emergency communication device** in storage areas [40 CFR 262.34(a)(4), 262.34(d)(4), 265.32(b)(c)].	5 (23%)
Managing hazardous waste **without a permit** [40 CFR 262.34(b)]	5 (23%)
Failure to **train or document training** [40 CFR 262.34(a)(4), 262.34 (b)]	5 (23%)
Failure to properly fill out **manifest** [40 CRR 262.20].	4 (18%)
Lack of adequate **secondary containment** [40 CFR 262.34(a)(ii)]	4 (18%)
Failure to **ensure delivery of haz waste to off-site** TSDF [40 CFR 2622.42]	3 (14%)

[a] Note that data is gathered from 20 different universities, but two of these had two campuses audited and therefore could have received the same violation more than once at different locations. Data are from the following schools in EPA New England, Region 2 and Region 9: Yale University; Boston University; University of Rhode Island; University of New Hampshire; Harvard University; Massachusetts Institute of Technology; University of Maine-Orono; U.S. Coast Guard Academy; Clark University; Eastern Connecticut State University; Montserrat College of Art; Dartmouth University; Merchant Marine Academy; Columbia University; College of Mount St. Vincent; Manhattan College; Georgian Court College; Pratt Institute; South Hampton College of Long Island University; University of Hawaii, and New York College of Podiatric Medicine. The list of common violations does not encompass all the violations noted in these reports, only those that appeared frequently. [c]Three of the 20 universities (Clark U, Montserrat College of Art, and East Connecticut State U) conducted self-audits as part of a new program in EPA New England that encourages schools to report to EPA and correct possible violations in order to avoid enforcement actions.

Based on a review of the 2001 data, it appears that both Boston College and UMB are cited for a number of the common RCRA violations. However, these schools also demonstrate a "higher awareness level" and few, if any, violations of emergency preparedness. Further, it appears that the mistakes are occurring less frequently at the XL schools and the violations seem to occur fewer times in individual laboratories and at fewer laboratories campus-wide at the three XL schools. However, it is very difficult to quantify, and objectively compare these violations across the XL and non-XL schools. Specifically, two factors preclude a more rigorous analysis:

- First, most non-XL audits did not identify the number or percentage of labs visited at each campus, thus preventing an even comparison across schools. In addition, the non-XL audits generally had a broader focus, which included all RCRA regulated buildings (e.g., art departments, vehicle maintenance departments, 90 day storage areas, etc.). In contrast, the 2001 XL audits focused exclusively on laboratories (i.e., chemistry, biology, geology, etc.). Therefore, it is difficult to quantify the number of times a RCRA violation was identified during an audit (i.e., the number of times a container went unlabeled, or the number of times secondary containment was missing) and then compare that number across XL and non-XL schools.

- Second, the inspectors did not use standardized language in evaluating the universities. For example, the three XL audit reports tend to be less quantitative in describing the number of violations (i.e., "a couple of locations" or "a few containers") whereas, the non-XL audits repeatedly found the same violations numerous times (i.e., “197 bottles” or “multiple shipments” etc). The data suggest relatively fewer violations at the XL schools; however, the terminology used by different RCRA inspectors makes it impossible to quantify the trend.

No EPA audit information exists for the XL schools before the XL program was implemented at the schools as no targeted enforcement efforts took place at these institutions. Therefore, there are no baseline data for these schools before regulatory flexibility was afforded to the schools under XL. The information presented below can be considered the baseline audit after implementation of the EMP. The audits were conducted at Boston College, UMB, and UVM during the 2000-2001 school year soon after the EMPs were implemented at the schools. The audits conducted at each university reviewed compliance with the regulatory flexibility afforded by the modification of RCRA Subpart J, the regulations that govern the temporary holding of hazardous waste in participating laboratories (often referred to as satellite accumulation of hazardous waste). In addition, the audits also examined compliance with and the efficacy of the EMPs at each campus during the first year of EMP implementation. The audits, however, did not review RCRA records other than those pertaining to Subpart J. The baseline audits were announced visits to the universities, who had approximately three weeks notice prior to the official visits. Audits for the 2002-2003 academic year will be unannounced visits and audit results will be compared to the 2000-2001 data to measure compliance progress.

This EPI is measured through the following four levels of inspections that take place over the course of the academic year:

(1) Self-inspections usually completed by graduate students or the laboratory safety contact. Self-inspections vary with each school in topics covered and frequency of inspections. The self-inspection forms for each school are presented in Appendix 8.

(2) Annual internal audits completed by EHS staff at each school. These audits are in-depth and require an extensive amount of time to complete. These internal audits look at the MPC, the EMPs and CHPs (where applicable), OSHA regulations, fire codes and recommendations outlined by the National Research Council.

(3) External audits conducted by a third party—C^2E^2 and other university representatives—in a small number of laboratories. The external audit looks solely at the Minimum Performance Criteria (MPC), which includes the following items: waste labeling; quantity of waste; removal times; excess accumulation; container closure; container condition; containers compatible; evidence of release; emergency response procedures; emergency equipment; worker emergency response; release reporting; waste movement; waste transportation; and training. These audits draw on the MPC, the Chemical Hygiene Plan, OSHA regulations, fire codes and recommendations outlined by the National Research Council. All three schools have adopted the laboratory audit grading system developed by C^2E^2, that converts the results of the laboratory audit checklist into grades on the following issues:

- Chemical container management;
- Laboratory housekeeping;
- Pollution prevention;
- Laboratory self-inspections; and
- Training and awareness.

The purpose of this revised "scoring" scheme is to develop a simple and consistent format for evaluating waste management practices at research laboratories at the three XL Institutions. This grading scheme is also designed to move beyond scores based solely on compliance with the Minimum Performance Criteria to include elements associated with prudent laboratory practices, environmental awareness and pollution prevention. An inspector/auditor conducts an audit of a laboratory using his/her own audit protocol or checklist. Based on the review (observations, interviews and/or records), a total score is generated based on the five categories. Container management has a top score of 3 while all other elements have a top score of 2. A minimum score for a laboratory is a zero. A maximum score for a laboratory is an 11. The schools used the zero score to illustrate the beginning of programs in the laboratory. For example, training in the EMP at UMB did not occur until 2001so laboratories were assigned a score of zero for the Training and Awareness category for 2001. The grading scheme is presented in Appendix 9.

(4) External audits conducted by co-regulators—EPA and the relevant State Agency—look primarily at RCRA compliance as it pertains to this project and EMP conformance. The external audit looks solely at the Minimum Performance Criteria (MPC), which includes the following items: waste labeling; quantity of waste; removal times; excess accumulation; container closure; container condition; containers compatible; evidence of release; emergency response procedures; emergency equipment; worker emergency response; release reporting; waste movement; waste transportation; and training. Discussions with laboratory workers also add data regarding pollution prevention efforts and environmental stewardship.

EPA and the States plan to conduct follow-up audits in fiscal year 2003, which would be unannounced. These audits will focus more on the EMP conformance with particular attention to the regulatory flexibility being tested with this project.

Boston College: The external audit was conducted on March 15, 2001 by C^2E^2 and health and safety staff from New England universities and colleges, who are also members of C^2E^2. Representatives from UVM also participated in this audit. Boston College EHS staff accompanied the external auditors. Two teams were formed each comprised of at least one independent, external auditor and one Boston College staff member. The teams each took a building (Higgins Hall or Merkert Chemistry Building) and visited two or more laboratories in each. This represents less than 10 percent of total laboratories participating in the XL project.

The external auditors recorded two items where more than one “infraction” was recorded among the seven labs visited. The most frequent problems were improper labeling. More specifically, the appropriate hazard classes were not correctly identified on the label. Another common observation was that writing on labels was smudged and unreadable as if the label had become wet. Other noticeable problems were container condition and storage. In one case bottles were piled in a secondary container. In another, waste storage was on the floor near a door in a high traffic area. In both cases, immediate corrective actions were initiated.

Members of the EHS staff conducted internal audits on most of the labs (some were omitted due to renovations and relocations). EHS procedure for internal audits involves the auditor sending two copies of the audit results to the PI or lab supervisor. The PI or lab supervisor signs and returns one copy of the report. EHS was not successful in getting the signed forms returned even after reminders and second copies were sent out. EHS had an approximate 50 percent return rate in two months with reminders. EHS is exploring another mechanism to ensure sustained communication between EHS and staff and greater accountability for the PIs and laboratory supervisors.

Internal audits were conducted in February and March 2001. After examining 25 internal audit records, the following problems were noted:

- Incorrect labeling—chemical names were abbreviated and hazard classes were not identified.
- Container management—storage of incompatible wastes, some open containers, and some containers missing secondary containment.
- Self-inspection—inspection of the laboratory waste storage area was not consistent or regularly performed.
- Emergency response awareness—laboratory workers needed to be reminded of the plan for potential emergencies, lack of centralization of spill kits and emergency phone numbers.

The EPA audit was conducted on April 23 and 24, 2001 by two EPA New England staff—the Project XL project manager and a RCRA inspector. Five departments at Boston College are participating in the XL project: Chemistry (Merkert Chemistry Center), Geology (Devlin Hall), Psychology (McGuinn Hall), and Biology and Physics (Higgins Hall). Most of the laboratories audited were research laboratories. Some teaching and preparatory areas were also inspected.

The auditors took notes on over 500 containers including bottles, bag, and cylinders. In general, the audit team was very impressed with the good working relationship that the EH&S staff had with each Department visited. The EH&S staff members appeared to be well-known in the laboratories and their suggestions were well received during the audit. Overall, the Departments visited demonstrated good housekeeping and waste management practices. In general, the Departments appeared to be aware of the requirements and following them with few issues. During the closing meeting (also attended by the universities' Project XL consultant and facilitator, Tom Balf, of Nexus Environmental Partners) the audit team reviewed certain issues. The vast majority of containers and laboratories were properly managed although the following problems were discussed:

a. The hazard class was being inconsistently applied on the laboratory waste labels. In some cases the class was not checked off, in other cases, waste containers of the same waste had different hazard classes identified.
b. Of the many containers seen, a few open containers were noted.
c. Many of the laboratory workers are filling in the date on the labels when they first begin filling a waste container. Although this is not an immediate nonconformance, under the regulatory scheme, it would indicate that the laboratory is temporarily holding 55 gallons of (or 1 quart of acutely hazardous) laboratory waste and that the waste must be removed within 30 days. Very few of the bottles that were dated were beyond the 30-day limit, however, none of the laboratories audited contained over 55-gallons or 1 quart of acutely hazardous waste. The auditors' impressions are that this practice results from inaccurate training during the first several groups of training.
d. There were instances of incompatible wastes (generally solvents and acids) being held in the same secondary containment bin. These instances were immediately rectified.
e. Secondary containment trays were absent in a few locations. EH&S addressed this issue during this audit.
f. Major deviation from the labeling scheme was noted in the undergraduate teaching area of Merkert with several different labels in evidence, including "byproducts", "recycle" and "non-hazardous waste" labels. The auditors did not see this issue in other areas where the laboratory workers were sometimes using old labels, but they clearly indicated that the contents were waste. The auditors understand from the audit that the undergraduate teaching laboratories often create one chemical in an experiment to be used in a second experiment, or otherwise reused. This needs to be addressed in the EMP and an appropriate and consistent labeling scheme should be developed. Some way to differentiate these types of products from laboratory waste, which has a very broad definition, should be investigated.
g. The HCOC process had not been through a complete yearly cycle at the time of the audit. It appeared to the auditors that the process at Boston College was addressing all chemicals and not highlighting HCOC as was intended by the new standard.
h. There were several discussions during the audit of the practices near sinks. There was a concern

that the specialized funnels being used could leak vapors and that the set-up, especially when next to a sink, could be knocked over and broken or spilled. Secondly, it appeared, from staining that was noted that some inappropriate chemicals, such as acetone, might be being used to wash glassware in the sinks.

i. It was noted that an older EHS policy (dated 6-94) was posted by a sink in Devlin Hall that stated that storage of chemicals near sinks or storm drains is prohibited. The auditors felt that this was a good policy to maintain and could be reiterated in current documentation.

j. The auditors noted the awareness level is quite high, and only one audited laboratory was missing the contact information. This was immediately rectified, and the information was posted during the audit.

k. The auditors noted that excellent groundwork had been set with the preliminary audit, and it was impressive to see the cooperation and respect that was noted during the audit. In the opinion of the auditors, Boston College's detailed program was showing great success.

Since the 2001 audits, Boston College instituted a new program to provide more frequent audit feedback of the waste areas in the laboratories. Boston College contracted with Triumverate Chemical to have a chemist conduct an inspection of the waste area in each laboratory. His findings are reported to personnel at the time of the audit and to EHS. EHS reviews the findings and identifies areas for further attention and topics for additional training. After receiving the audit results a student worker "grades" the audits according to the audit scorecard developed by C^2E^2. The student used the grading procedure for the 2001 and 2002 audits to provide a basis for comparison. The student is an objective third-party, as he does not know the laboratories and was not involved in the audit. The following table (Table 11) presents the graded results of the audits for spring 2001 and 2002. The laboratories could receive a total of six points, "6" being the highest rating and "0" being the poorest rating.

Table 12: Audit Grades Comparison

Department	Average Total 2001	Average Total 2002	Percent Change (%)
Biology	4	4	0
Chemistry	3.8	4.9	30
Geology	4.5	6	33
Physics	3	3.5	17

The audit results reflect only scores for Container Management and Housekeeping/Safety. Three out of four laboratories showed improvement, and one did not change. These scores do indicate a trend of enhanced knowledge and competence in laboratory workers.

University of Massachusetts Boston: C^2E^2 and a health and safety member from Worcester Polytechnic Institute, Massachusetts conducted the external audit on April 4, 2001. The audit included the following laboratories and departments: one from anthropology; three from biology; four from chemistry; three from ECOS; and two from psychology. The most common and consistent problems observed during the audit concerned labeling. In many cases, the laboratory waste "tie-on" labels were filled out incompletely or incorrectly, or were not being used at all. Other common problems with labels included labels being filled out incompletely or incorrectly, or were not being used at all. UMB used the C^2E^2 audit grading system for 2000 and 2001. In both years, UMB only used completed laboratory inspection forms. In 2001, only 104 laboratories were analyzed as some of the forms were missing. Between 2000 and 2001 there was a 51 percent increase in total grades for laboratories. For the next round of inspections, audit grading forms will be included during the actual inspection. The results of the grading system are presented below in Table 13.

Table 13: 2001 UMB Average Audit Scores

	Average Score 2001
Container management	0.63
Housekeeping	0.75
Pollution Prevention	1.0
Self-inspection	0.38
Training	0.26
Total Average Score	**5.02**

The internal audit began in June 2001 and was completed in mid-August 2001 by EHS personnel. All laboratories on campus part of the XL program were audited. The common problems observed during the external audit were not noticed during the internal audits. EHS attributes better performance to more emphasis on the problems during training sessions that took place in the interim. The problems observed by EHS during the internal audit included open containers and improperly filled out laboratory waste "tie-on" tags. The most common problem with the tags was that laboratory workers identified the date that waste accumulation begins rather than dating the container when it became full or deemed ready for pick-up. All deficiencies were immediately corrected. EHS worked to tailor the training session to address any outstanding issues.

The EPA-State audit was conducted on May 14 and 18, 2001 by three EPA New England staff—the Project XL project lead, Project XL coordinator, and a RCRA inspector—and by an official from the MA DEP for part of the audit. The Anthropology, Biology, Chemistry, ECOS (Environmental, Coastal and Ocean Sciences), Geography, Physics and Psychology departments are participating in this project. All of these departments are located in the College of Arts and Sciences. Laboratory wastes generated from these laboratories are transferred to the hazardous waste accumulation area in the Garage, however, that space is currently undergoing renovations and laboratory waste is being temporarily accumulated with the chemical storage on the upper level of the Science Building. UMB has a Large Quantity Generator number for this accumulation area.

The audit team visited over 90 laboratories. Most of the participating laboratories are research laboratories, however, there are a few teaching laboratories that do not temporarily hold waste. All wastes, not just laboratory wastes, are accumulated at the LQG area (which is temporarily located in the Science Building). During the entire audit, the auditors took notes on over 130 containers including bottles, tubes and pails. The majority of these containers were properly managed although some problems noted are detailed below:

a. Hazard class was being inconsistently applied on the laboratory waste labels. In some cases, the laboratory worker used a hazard class that was not one identified in the CH/EM plan, occasionally the hazard class was not checked off, and in other instances the waste containers of the same waste had differing hazard classes identified. The efficacy of including the hazard class also should be addressed in reviewing this pilot since it is not clear from this audit whether adding the hazard class to the label requirements has any positive impact on waste management. The auditors noted that it may be appropriate to use the hazard class identification to determine which bin the waste should occupy the main accumulation area, even though the labeling schemes did not match at the time of the audit.
b. Many of the laboratory workers are filling in the date on the labels when they first begin filling a waste container. Although this is not an immediate nonconformance, under the regulatory scheme, it would indicate that the laboratory is temporarily holding 55 gallons of (or 1 quart of acutely hazardous) laboratory waste and that the waste should be removed within the 30-day limit. However, none of the laboratories audited container over 55-gallons or 1 quart of acutely hazardous laboratory waste. The auditors' understanding is that this practice results from inaccurate training and/or from a desire to note when the container is first put into use.

c. There were one or two instances of incompatible wastes (generally solvents and acids) being held in the same secondary containment bin. These instances were immediately rectified.
d. Secondary containment trays were absent in a couple of locations.
e. Some wastes in the Biology Department were not properly labeled. The wastes were removed during the audit.
f. The Hazardous Chemicals of Concern (HCOC) process had not been through a complete yearly cycle at the time of the audit. UMB is in the process of switching to a bar-coding system. This system should be documented.
g. One in-line waste collection system did not have a waste label on the waste bottle, but the instrument had recently been moved into the newly renovated laboratory and did not appear to be in use.
h. The hazard classes of some waste materials and whether certain wastes fit the definition of laboratory waste (biological sharps) are open questions. Certain non-RCRA wastes, such as the biology sharps, are sometimes labeled as laboratory waste and sometimes not. Some gel and staining wastes are labeled as toxic laboratory wastes where it is not clear that they are toxic. Review of what hazard class to use and how to label some of the non-hazardous waste would be appropriate.
i. The auditors noted that excellent groundwork had been set. The number of laboratories that are working with the new system impressed the auditors. Equally impressive was the good working relationship displayed between the EHS staff and each Department contact. The EHS members appeared to be well known in the laboratories where there were researchers during the audit. Overall, the Departments visited appeared to be aware of the requirements and to be following them with the few issues noted above.

During the closing meeting at UMB, attended by several Deans and Department heads of the associated laboratories, the audit team reviewed the aforementioned issues. The auditors noted that the UMB environmental management standard program has made substantial progress in its first year of implementation and further planned enhancements will add to the program "…that has already shown significant accomplishments."[21]

<u>University of Vermont:</u> The vast majority of UVM's laboratories involved in the XL project are located in the main campus in Burlington. The laboratory waste generated on the main campus is brought to the Given Bunker (located on campus), pursuant to the EMP. The Given Bunker is the only location designated under the EMP as an accumulation area, where laboratory waste is collected and first becomes subject to the requirement for making a hazardous waste determination. For a number of years, the Given Bunker has been managed as a "short-term hazardous waste storage area" for less than 90-day accumulation of hazardous waste generated on the main campus. From the Given Bunker, hazardous waste generally is transported directly to UVM's Environmental Safety Facility (ESF), a certified hazardous waste storage facility. The ESF is located approximately one mile from campus, within the Burlington city limits. All laboratory waste generated at off-campus locations is brought directly to the ESF. Hazardous waste is shipped from the ESF for further storage, treatment or disposal out of state. UVM generates a wide range of laboratory waste including outdated chemicals, spent chemical solutions, and unused chemicals no longer needed for laboratory and research projects. The majority of UVM's laboratory waste is generated at two main campus locations—the Given Medical Complex and the Cook Chemistry Building.

UVM uses a chemical waste tracking system that is based on a multi-copy "laboratory waste TAG" that meets the FPA Project XL container labeling requirements. When a container of laboratory waste is ready for pick-up, the waste generator fills out a TAG and sends the top copy to the ESF while affixing the remaining copy to the container. ESF personnel enter the TAGs data into a computerized database used to schedule waste pick-up. Laboratory waste that is picked up and brought to the Given Bunker is evaluated for potential reuse and laboratory waste that cannot be reused is evaluated to determine if it is subject to regulation as a hazardous waste.

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[21] University of Massachusetts-Boston Year 1 Audit Report completed by EPA New England. July 12, 2001.

In June 2001, 291 (approximately 48 percent) of campus laboratories have been through the internal audit process. Out of these laboratories, 115 (42 percent) have completed the audit process by notifying ESF that corrective actions were taken on noted deficiencies. In July 2001, the Chemical and Biological Safety Committee was notified if any laboratories had outstanding corrective actions to fix discrepancies. The second round of the internal audits were initiated in the fall of 2002.

The external audit was conducted on April 9, 2001, approximately four months after the EMP was approved by VT DEC and implemented. The audit team consisted of four members from the health and safety departments of other New England colleges and universities, recruited by C^2E^2. A representative from UMB was a participant in this audit. UVM ESF staff assisted the audit team members. Four teams, each comprised of one external auditor and one UVM staff member, visited randomly selected laboratories in each laboratory building on campus. The teams assessed compliance with the MPC in the laboratories, and where appropriate, advised laboratory workers of any deficiencies and appropriate corrective actions. The audit looked at the following items: waste labeling; quantity of waste; removal times; excess accumulation; container closure; container condition; containers compatible; evidence of release; emergency response procedures; emergency equipment; worker emergency response; release reporting; waste movement; waste transportation; and training.

The teams visited 48 laboratories all together (this represents only 10 percent of the total number of laboratories participating in the XL project), 29 of which had no more than one deficiency reported. The most common problem found concerned the proper labeling of laboratory waste; 50 percent of the laboratories visited had some deficiency in this respect. Other significant problems included container closure issues (21 percent of laboratories visited); evidence of release of chemicals within the laboratory (12 percent); and over accumulation of laboratory waste (17 percent). All other deficiencies were found in less than 10 percent of the laboratories visited. This audit was not a complete review of all laboratories or on the EMP conformance. Therefore, it is not possible to directly compare the results of this audit with the baseline audit conducted by EPA in October 2001. However, labeling deficiencies is one common area from both audit reports.

UVM applied the C^2E^2 grading system to its 2001 audits, the first year under the EMP. A total number of 532 laboratories received a grade score. The average scores for the laboratories based on five criteria are presented below in Table 13. The total average score for all laboratories across all categories was 3.16. No laboratories at UVM scored above a 3, and only 64 laboratories scored a 3 in the area of container management. In the remaining categories, laboratories were in the 0-2 range. The standard deviation is presented to illustrate the distribution of scores about the total average score for all laboratories and laboratory characteristics. It is a measure of how precise the average is and numerically depicts how well the individual numbers agree with each other. The relative standard is the standard deviation expressed as a percentage of the total. UVM has set a goal for the next round of audits to show a 50 percent increase over the average audit score.

Table 14: Average compliance grades for UVM laboratories

Laboratory Characteristics	**Average Grade**	**Standard Deviation**	**Relative Standard Deviation**
Container management	1.48	0.79	53%
Housekeeping	0.42	0.72	169%
Pollution Prevention	0.25	0.44	172%
Self-inspection	0	0	0%
Training	1.01	0.75	74%
Total Average Score	**3.16**		

VT DEC is the lead agency designated by EPA for oversight of the XL project and therefore, was the lead on conducting the audit at UVM. Two VT DEC staff from the Waste Management Division, and two EPA New England representatives conducted the audit on October 15-18, 2001. The auditors utilized a checklist developed prior to the audit so that consistent observations could be recorded regarding specific aspects of the XL project.

Although the auditors clearly had noted the good work done to date, UVM was the last of the three universities to implement its EMP; therefore it was slightly behind the other two schools in implementing the new standard. The following areas were noted for improvement:

a. A number of laboratory waste containers that had been tagged more than 30 days prior to the audit, and some containers that had been tagged, but the "white copy" of the tag had not been removed and sent to ESF (facilitating removal of the waste).
b. A number of other container management problems (i.e. incompatible wastes stored together, containers not managed to avoid leaks, incomplete labeling, open containers, and glass bottles of waste stored on the floor or in the walkways).
c. A few of the fume hoods observed had been certified according to the "Proper Fume Hood Use" procedure included in UVM's EMP. Although not a RCRA/hazardous waste issue, the certification of laboratory fume hoods was evaluated as the EMP procedure requires annual certification.
d. Documentation of laboratory self-inspections was not done consistently as over 55 percent of the labs visited either never documented self-inspections or only documented them on occasion.
e. Most significantly, the main chemical stockroom in the Cook chemistry building was functioning as an XL accumulation area, but was not being managed accordingly. Within the chemical stockroom, auditors observed incompatible wastes being stored together, numerous unknowns, and laboratory waste that was neither tagged nor labeled.

According to the audit, UVM has made a great deal of progress in training laboratory workers, upgrading laboratory procedures, removing old chemicals, clearing out unwanted laboratory byproducts and preparing and distributing spill kits and EMP documentation. Specifically, the auditors pointed out that the following were working well in laboratories:

a. Nearly all of the UVM laboratory workers interviewed had attended "Environmental Awareness" and "Chemical Safety" training seminars put on by UVM's ESF staff. Most laboratory workers knew whom to call in the event of a problem, and where spill kits were located. It was also apparent that ESF staff had been quite active in the laboratories as, almost without exception, laboratory workers recognized the ESF staff that the auditors visited.
b. Most of the Principal Investigators said that they had completed the HCOC inventory.
c. UVM had made a significant investment in new waste management and safety equipment (e.g., spill kits, chemical storage cabinets), and in upgrading some of its waste management infrastructure (e.g., renovations to the chemical storage room).
d. Many of the labs visited did not contain waste that, outside the scope of the XL project would be regulated as hazardous waste. Many of these labs still met the stringent XL standards.
e. The ESF staff had audited many of the labs; in many cases, lab workers showed us copies of documentation verifying that the problems identified by the ESF audit had been addressed.
f. Due to the chemical waste clean-outs that occurred during the summer 2001, much progress had been made in the overall condition of the main chemical stockroom for the Cook chemistry building.
g. A few of the faculty members had given pollution prevention and waste reduction serious consideration with respect to the work done in their labs.

Findings: A separate question was touched on with this project—are RCRA violations *less common* at the XL schools than compared to the larger universe of colleges and universities? As one example, based on a review of the violations noted in the October 2001 audit report for UVM, it appears that EPA noted a number of RCRA violations at UVM that are similar to those at other, non-XL schools. However, a great

deal of progress has been made at UVM in terms of awareness training, removal of old chemicals, and the availability of spill kits in laboratories. RCRA inspectors at these schools could say that the severity and magnitude of errors at the XL schools are less than their counterparts without an EMP and required training programs. Therefore, there appears to be at least some qualitative improvement at UVM over the non-XL schools, particularly with respect to better emergency preparedness. In general, due to the sparse data on audits and the existing laboratory management programs in place at other academic institutions, it is difficult to do a direct comparison. Although it is not possible to state that the XL project indeed improved compliance, the schools have shown that other EMP components are in place and should continue to be improved in order to have an impact on future compliance rates in the laboratory. The XL schools are inspected (both by the EPA and the States, and internal EHS staff) on a more regular basis compared to most other colleges and universities during the course of the academic year. In general, frequent inspections are helping prevent pervasive compliance problems from existing without corrective actions taking place. However, EHS staff at Boston College noted that self-inspection forms were being returned every week with the statement that all laboratories were in compliance while the subsequent audits (external and internal) revealed otherwise. Additionally, participants in the group discussion at Boston College noted that the safety contacts that perform the self-inspections may feel restrained correcting their peers on laboratory practices or it is often the case that other students are unaware that self-inspections are even completed every week. This is probably not unique to Boston College. Given that there are a number of checks going on periodically during the year, the question remains as to why there are compliance issues in these laboratories.

Some of the infractions at the XL schools do not meet high priority violation status—they included improper secondary containment, inspection forms not fully completed, issues such as labels not filled out correctly—the schools need to think creatively about how to raise the level of accountability for laboratory management instead of the burden for compliance being solely on the shoulders of a small number of EHS staff at each school. Some of the mistakes made in the laboratory seem to originate from sloppy laboratory practices—filling out labels with non-permanent markers, not closing containers—which are practices that can hinder research in addition to being health and safety concerns. The problem of co-locating incompatible wastes is a larger issue to deal with since it requires a more substantive knowledge of the chemicals and the regulations, and then it requires people to behave accordingly.

What is abundantly clear is that compliance is inextricably tied to access to knowledge and information about correct procedures and an individual commitment to performance. With these four inspections taking place, there is a good system in place to ensure long-term compliance with the EMP. Yet, for the remainder of the project there remains much work needs to be done on achieving compliance in the short-term. There appear to be two fundamental issues at work here. The first is whether the laboratory personnel have the knowledge and tools to comply? The answer to this question is yes. EHS staff from all three schools have shown that their trainings are timely and that their curricula are flexible to incorporate new issues that are raised. The results presented on the training EPI further supports the idea that EHS is reaching out to an increasing number of individuals and that the trainings are having a positive effect on people. However, the extent of the effect is unclear. The second issue is whether or not knowledge and understanding of the issues translate into behavioral changes. Training, unfortunately, does not necessarily change the behavior of the individual, which in an academic setting is critical as most of the responsibility is on the individual laboratory worker.

Compliance in a laboratory is largely dependent on the actions of the individual, and the power that an individual wields in the academic setting. For example, in each school EHS staff cited at least one Department Chair who is firmly committed to the XL project. For the most part, those select departments are more cooperative when it comes to regular training and EHS is kept up to date on who has been trained within the department, laboratories welcome EHS input and interactions, self-inspection forms are returned to EHS in a timely manner, and there is a real sense of partnership. The top-down commitment to this project translates into faculty, staff, and students knowing what is expected of them and in turn performing appropriately. In general, compliance in these types of scenarios is greater than in other departments where commitment from top personnel is less. In fact, in cases where EHS has identified intransigent faculty or Department Chairs, the lack of commitment from top personnel allows one or two individuals (or even a whole department) to remain stumbling blocks to improving laboratory management and performance. The schools can address both of these issues in a few ways.

Recommendations: EHS staff at all three schools should continue with their extensive work on training and remain open to adapting training to new needs, questions and issues that may arise in the laboratory. As long as information is accessible, understandable and provided with frequency, EHS staff will be able to expose more individuals to good laboratory practices. The traditional ways of changing behavior are through increased control or incentives. Given that EHS staffs have limited resources and means, there are some creative sticks and carrots that EHS can explore.

First, EHS staff could try and exert more "control" to shift the burden of accountability to the individual. Boston College is currently exploring this option to have more people sign their audit reports and to ensure that people are taking the extra few minutes to ensure that the self-inspections truly do reflect what is occurring in the laboratory. Boston College is in the process of performing random verifications of the self-certification forms by using their waste management vendors to verify compliance. EHS plans to negotiate in the contract four spot-checks per year of selected laboratories, and if there are problems, the contractor will indicate them to the laboratory staff before reporting it to EHS. The use of the vendor can extend the "arm" of EHS into the laboratories and keep a more detailed watch for issues as they come up on a daily basis. It is unclear whether this is a resource intensive proposition, however, if this option is not available to UVM or UMB, these laboratory spot-checks can also be performed by a student intern, possibly as a work-study option for students on campus. This should be a less expensive option, and it would also help extend EHS reach into the laboratories.

Second, EHS can try and provide incentives for better behavior. One approach is to highlight those laboratories performing exceptionally well to the school Administration during reports. EHS can work with the Administration to see if there are ways in which certain Department Chairs, faculty, or even whole departments can be recognized for further advancing the goals of the NEU Labs project. This may elevate the status of the project and raise the performance expectation for others. The other recommendation for an incentive was suggested for graduate students who were performing valuable services in the laboratory. Again, recognizing individuals may change the overall behavior in the laboratory. A small-scale annual recognition program can be that EHS recognizes high performing laboratories by purchasing a small stock of necessary chemicals for the laboratory, or mid-cost laboratory equipment that is needed. There are many variations on incentives, which can be pursued to try and promote better behavior that do not have to be overly resource intensive. For example, UVM could use the Vice Provost for Research to promote recognition programs of departments or individuals, as he is a champion of the XL project. Similar to the regulatory context, some combinations of carrots and sticks at the university level are going to be necessary to improve behavior in the laboratory.

Section 10 Lessons Learned to Date

Work within the challenges of an academic culture—capitalize on the benefits of an academic culture.

In order to achieve objectives of long-term sustained behavioral change and environmental performance in laboratories there are some cultural hurdles that perhaps EHS and future regulations will have to take into account. Many of these have been discussed in the preceding section, however they bear repeating, as they are real barriers.

- PIs performing high-level research will most likely not use previously owned and opened chemicals that have been in the custody of EHS. In some cases, researchers will consider using opened chemical powders, where it is possible to test chemical purity, however it is highly unlikely that a researcher will use an opened liquid. The exception to these research norms is that chemicals will be shared between laboratories that are trusted sources.

- Scientifically acceptable research protocols often dictate the amount and types of chemicals used even if the inputs are intensive. It is difficult to change processes and methodologies that are not scientifically tested or readily accepted protocols, therefore making pollution prevention at the point of experimentation all the more difficult. In addition, research funding from large grant institutions like the National Institutes of Health, do not stipulate and do not seem to reward pollution prevention in laboratory work. The large grants are highly competitive and the research is fast paced, requiring scientifically proven methodologies are required.

- If regulations disrupt the research process, it is likely that the regulations will come second to the work going on in the laboratory.

- Intransigent faculty and researchers that are unwilling to change their behavior to comply with regulations are likely never to change their behavior given the academic culture unless faced with serious pressure from senior Administration officials.

- Department chairs that are champions of the project in most cases have higher rates of compliance in their laboratories. Equally, those Department Chairs that are non-responsive to EHS and this project have more laboratories that are deficient in compliance and other EMP requirements.

- Laboratory compliance is determined by many and can hinge on one individual's actions or lack of action in the laboratory.

- Responsibility and accountability are not straightforward in university research settings, where the funding is often decentralized and written job descriptions do not exist for many workers.

- The decentralized and changing nature of scientific research makes it difficult to track laboratory progress and to keep track of staff training.

Yet, there are some unique qualities to the academic community that facilitate more partnerships with the regulators and communication on ways to improve laboratory regulation and performance. The following positive attributes were noticed at all three XL schools:

- The sector understands the importance and necessity of environmental regulations in the laboratory. A common theme expressed at all schools was that faculty; staff and students will comply with the regulations as long as the requirements do not interfere with the research and if the requirements "make sense." Therefore, it may be necessary to ground-truth laboratory requirements to see where these boundaries may arise. No one in the group discussions ever once stated that laboratories should not be regulated, and there was always a statement to the effect that discussion participants "…know that the regulations serve a purpose and that regulations should exist in the laboratory setting." Given that there is no outright defiance against environmental, health and safety regulations, regulators need to make every effort to work with this particular regulated community to ensure that practical and enforceable regulations for laboratories are crafted.

- A common theme expressed during group discussions was that the EMP made the regulations straightforward, unambiguous and made it clear "what was expected of them [the discussion participants]". The regulators and EHS staff are dealing with population who are generally aware of environmental, health and safety issues in the laboratory and potential impacts do appreciate when steps are taken to simplify and facilitate their research operations.

- Compliance is so dependent on individual actions that training, rewards and recognition, and increased "enforcement" by EHS could result in significant benefits that can also be diffused.

- Students at all three universities cited how excited they were that their universities were in a "cutting edge" program. In addition, environmental awareness is already instilled in this generation of students so that they are more willing to change their behavior and to learn new techniques to improve environmental performance.

- Students should always be utilized as motivators for change since they are in an academic setting to learn. Learning about proper research techniques that are also sound environmental, health and safety practices will make students more marketable for their careers and can enhance overall environmental awareness that can be carried beyond their academic training. EHS and interested staff will benefit from engaging students in P2 efforts and in creating a more formalized recognition system for those that are involved in overseeing day-to-day laboratory operations.

- Based on group discussions it is clear that faculty, staff and students are mostly aware that there is a sense of purpose and mission with this XL project. Even though there is room for improvement, the schools should be recognized for publicizing the project goals and purpose, for investing time to create a working management program with the EMP, and for their willingness to partner with the regulators to try an innovative approach on the "cutting edge" of performance-based regulation.

- The school discussions provided a good opportunity for EPA and the States to hear first-hand that many people appreciated the opportunity to partner, to have frequent feedback from the regulators, and to work together to solve problems in the laboratories.

Prioritize EMP elements to improve environmental performance over the remainder of the project by focusing on pollution prevention.
As stated earlier, a key component to Project XL is demonstrating superior environmental performance (SEP). The goals set in the project to reduce hazardous waste generation, increase chemical redistribution, and investigate P2 opportunities in laboratories were meant to provide the SEP beyond what the current regulatory system can achieve. For reasons identified many times in this mid-term evaluation, it is extremely difficult for the schools to attain the waste reduction and the chemical redistribution EPIs. Therefore, the schools should re-direct the focus of their attention for the remainder of the project to exploring and implementing P2 opportunities in schools as the priority SEP element, as it is most promising to achieve lasting environmental improvements. EPIs 4 and 5, while worthy goals that should not be forsaken, are so dependent on research grants and the types of research being conducted that any progress made during one semester can be easily erased in the next. Accomplishing more P2 (EPI #3) is one area that can have permanence in laboratories, is attainable and is most transferable to other laboratories and schools. The schools need to formulate an aggressive timetable for beginning discussions with their faculty, students and staff to explore all available P2 options—keeping in mind that P2 does not necessarily have to occur on a grandiose scale.

Improve EMP compliance
The audits from the three schools generally indicate two things:

1. It is impressive that in almost all laboratories staff and students were familiar with EHS staff and most had received laboratory training.

2. The schools are still having difficulty complying with some of the Minimum Performance Criteria—the EMP elements that most closely mimic the RCRA regulation they are meant to replace.

For example, although this is not a requirement, one graduate student at Boston College stated that he thought it would be "impossible" to have everyone in the laboratory write down the full chemical name on a label. Properly filling out laboratory waste labels is a common problem. Why this is so difficult for people to comply with should be explored and proper labeling requirements should be reinforced in training. Given the number of chemicals, the length of chemical names, and the various definitions of hazard class, it may be more important to explore whether it is necessary to have so much information on a label or whether common laboratory abbreviations, which is most often what auditors saw on labels, define the contents sufficiently.

EHS, EPA and the States (where applicable) should consider what might be best regarding chemical labeling in the regulations, as well as what is the best way to improve compliance or accuracy on correctly labeling hazard classes, if necessary. Federal RCRA regulations require only ***either*** the words" hazardous waste" ***or*** the contents, whereas many states require both, and some states additionally require hazard class. It was obvious during the audits that the way the hazard class was being applied was inconsistent, however, it was not clear what purpose is served by including the hazard class on a label that already includes the words "laboratory waste" and the contents of the waste. Laboratories use such a variety of chemicals (e.g., chemistry departments use a different suite of chemicals than the biology department) that the hazard class categorization would have to be quite complicated for it to clearly cover all possibilities. It is unlikely that a complicated scheme will be successful. For existing hazard class schemes, such as the toxic, ignitable, corrosive or explosive scheme it is not always clear what class a waste falls into, and some laboratory workers were using more than one hazard class (such as corrosive and toxic) and some were not. The project needs a way to measure the utility of a regulation where compliance shows confusion on the part of the regulated community, as demonstrated by inconsistencies in compliance.

Once all options are investigated to make the system easier to comply with, the bottom line here is that the requirements do need to serve a purpose and EHS must have the tools and resources necessary to improve compliance—either through rewards or through their own type of self-policing. Most importantly in the near-term, the schools need to prepare those laboratories cited in the 2001 EPA and State audit for the next audits, which will be unannounced. EPA and the States should expect to see improvements from the 2001 audits. The schools know what the regulators are looking for and know exactly what mistakes were found in the 2001 audit. At the very least, the schools need to be prepared and should expect that the auditors will be ensuring that those mistakes have been remedied and deficient laboratories have improved.

Create a system of accountability. EHS staff at all three schools need a better suite of tools—both incentives and self-policing—to create a partnership with laboratory staff, faculty and students to improve laboratory management.
As discussed in previous sections, EMP compliance and P2 are the two areas that the schools will need to improve on for the remainder of the project. In order to do this, a focus on training alone will not suffice. School administrators need to support EHS staff in their efforts to improve performance in those departments and laboratories where EMP compliance or cooperation with EHS staff is lacking. In many cases, a top-down re-affirmation of the XL project will help ease the way for EHS to work with deficient laboratories. Possible "carrots and sticks" were discussed in the preceding sections. The key to establishing accountability for laboratory performance is that it requires an investment of time into working with individuals and into creating more options for expanding the reach of EHS into laboratories.

Performance measurement goals may not always be the right measures and can overly narrow the focus of the project and overwhelm project implementation.
The EPIs for this project were designed to measure success in terms of the superior environmental performance, a criteria for an XL project. However, one of the project goals was also to formulate a better

regulatory scheme in return for superior environmental performance. The schools, EPA and the States are still trying to determine appropriate ways to measure whether these goals have been achieved. Early on in the project, there were many discussions on a number of issues pertaining to the Environmental Management Standard and the EMP. Those discussions have not yet been resolved and therefore add to confusion on the best way to measure the goal of a better regulatory scheme. For example, discussions continue on whether chemical abbreviations on a label meet the requirement for contents labeling, whether some wastes (such as biological sharps) meet the definition of laboratory waste, how to determine whether chemicals are outdated and should be removed from laboratories, and what hazard class means.

Top college and university Administration support is crucial and it has to be reinforced periodically.
The enthusiasm for this project comes both from the laboratory community as well as from each school's Administration and top Administrators. Top officials sign environmental policies for each participating school, which demonstrates commitment and accountability at very senior levels of the universities. There are many day-to-day and month-to-month activities associated with environmental management, but as in any endeavor, continuous improvement only occurs if the feedback loop is complete and operating smoothly.

There are benefits to coupling health and safety requirements with environmental regulations.
A recurring theme from the group discussions is that simplifying requirements—especially those that overlap—and having one consistent training session has greatly improved staff and students' abilities to understand what is required of them. Although this is a qualitative affirmation of the benefits of combining the Chemical Hygiene Plan and the Environmental Management Plan, it should be expected that as time passes with the EMP in place the quantitative data—training numbers and EMP audit results—should reflect that the EMP approach is improving laboratory performance. From the EHS perspective, it is clear that while some extra time is added to the overall training, implementation of an EMP has greatly improved the efficiency of EHS staff to deal with improving environmental and health and safety performance of laboratories rather than managing two distinct regulatory regimes.

Benchmarks and baseline information are necessary to be able to measure progress.
Progress would have been better measured under this project if actual baseline audits at the participating schools took place prior to EMP implementation. Secondly, baseline information should be quality and complete data sets in order to fully be able to measure progress. The schools did set up a system of measuring benchmarks, however they need to serve as a solid reference point for measuring progress over the remainder of the project. The schools should also think about using the environmental, health and safety benchmark information collected by the Campus Safety Health and Environmental Management Association (CSHEMA) from participating academic institutions. These benchmarks may provide useful information on how the XL schools are doing in comparative areas to non-XL schools. The CSHEMA benchmarks are presented in Appendix 10.

Reporting consistency is critical to improve data quality and measure progress.
The schools need to stress data consistency in their reporting over time. For example, information presented in the annual report from 1999 is not reflected in 2000 or in 2001. The schools can simplify their reporting by using one information template and by detailing which initiatives remain in progress, new projects started, or efforts retired. Without consistent reporting, it is difficult to explain results and measure progress.

Focus on the long-term benefits of training. Answer the questions of "why" in addition to focusing on the "how."
Training is supposed to improve laboratory practices, improve EMP compliance, and to provide knowledge to raise the environmental awareness of students and staff. The group discussions reinforced a finding of the environmental awareness survey—students and staff are not aware of the overall environmental impacts of a laboratory. At all schools, very few of those surveyed were able to answer correctly that greatest environmental impacts of a laboratory are energy related. Although energy efficiency of the laboratory is not tackled in this project, it is indeed an exceedingly important consideration and should be reinforced in training. In addition, students who participated in the group discussions stressed the benefits of knowing what happens to waste when containers are picked up and why the regulations are crafted in a certain way.

Students felt that if more individuals knew what happened to laboratory waste (i.e., that it is shipped away and is often incinerated) more students would be interested in looking for P2 opportunities and would be more sensitive to everyday activities in the laboratories. While it is still of utmost importance to stress how laboratories should be properly managed, it is clear from the on-campus discussions that time spent on addressing why it is important to properly dispose and store waste and how waste could impact the environment could result in behavioral changes.

Create more opportunities for EMP users to be instruments of change in the laboratories.
One of the benefits of holding group discussions on the campuses was simply gathering people who are affiliated with the EMP to discuss the overarching goals of why the EMP is important and what it is the schools are trying to achieve. This simple act started generating new ideas at the schools and some excitement of using this project to push the limits of what can be accomplished (environmentally) in the laboratories. EHS should encourage and sponsor ad hoc groups to meet at least once during an academic year to discuss one issue—be it P2, training, or implementing a student laboratory safety contact recognition program.

Long-term attitudinal and behavioral change is possible with training and extensive communication.
One of the most positive aspects of this project so far is that all group participants expressed that there was a feeling of something better happening on the respective campuses due to the XL project and more directly with the EMP. To look back at the associated logic model for this project—this is a long-term outcome for this project. It is possible to say that the general good feelings and heightened environmental awareness lead to the long-term attitudinal changes taking place—people are more open to EHS staff, they are more familiar with EHS staff, they ask better questions—and what needs to be improved on is achieving long-term behavioral changes. These will be measured primarily through the Environmental Awareness Survey, training, and EMP compliance.

Training and constant feedback to and from the EHS department on what is working, what remains unclear, where people are succeeding, and the support of school Administrators are the real ways in which behavioral shifts can occur in an academic setting.

Utilize institutional champions.
The schools need to make use of those individuals and Administrators who are supportive of this project and recognize the value of having this project succeed. This is going on to some extent at all of the schools informally, however there may be more formal ways in which these individuals can be used to further improve the program. These champions may prove pivotal in obtaining P2 goals for the remainder of the project, as they would be the most willing to implement or research P2 opportunities.

Section 11—Conclusion

Based on this mid-term assessment of this project, one can say that there is improvement in the range of activities that determine compliance, there is a marked shift in attitudes and behaviors, and that the environmental management system approach to managing laboratory waste in the three institutions seems to be working to achieve the stated objectives of the project. Looking forward, EPA, the states and the schools should continue to work together to strengthen this innovative partnership and to continue to seek out solutions to some of the difficult challenges that still remain.

As the universities, States and EPA systematize their abilities to creatively solve problems there are greater opportunities for all involved in this project to seek environmental gains in other areas not solely focused on laboratories, but hold great promise for these schools who can be called innovators. Energy efficiency in laboratories, enhanced and holistic chemical management programs, and exploring multi-media environmental management systems on college and university campuses will be the next superior environmental performance horizon for the project partners to tackle.