Boston College Annual Report on Project XL
June 30, 2004

Introduction

This report presents the results for Boston College (BC) laboratories[1] under the New England University Laboratory Project XL (henceforth referred to as Project XL, or the Project) for the year 2003. The report will discuss our experience using the Environmental Management Plan at BC. Waste data represent activities for the calendar year 2003. Other activities and data represent the Boston College fiscal and academic year, June 1, 2003 – May 31, 2004.

Environmental Management Program for Laboratories

In September 2000 Boston College initiated a waste management program for laboratories under Project XL. The program, written in The Boston College Environmental Management Plan, September 2000, spells out the waste management practices employed by workers in BC's laboratories, as well as the responsibilities and activities of the lab workers, their supervisors, and the Environmental Health and Safety (EHS) staff. The program is available on line at:
http://www.bc.edu/offices/facilities/ehs/library/programs/

Meeting Minimum Performance Criteria

The Final Project Agreement with the EPA spells out Minimum Performance Criteria (MPC) "to ensure the proper handling and management of laboratory waste." These criteria are met at BC through the cooperation of a number of key players, including the EHS staff, personnel from our hazardous waste contractor (Clean Harbors), the Department Chairs, the administrative staff who manage operations in each department, the University Chemical Hygiene Committee, the departmental safety committees, the principal investigators, and the lab workers, who are predominantly graduate students, plus a small proportion of post-doctoral fellows and research support staff.

Each laboratory worker is introduced to the Laboratory Waste Management Program early in their career at BC (fulfilling the requirement of Minimum Performance Criteria item j). There are training sessions in Chemical Hygiene and Waste Management at the start of each semester and the summer. The training reviews the unique labeling requirements as well as the standard waste management procedures. BC's Laboratory Waste labels are designed to communicate the appropriate amount of information to the waste handlers (Clean Harbors personnel) who pick up waste in labs and move it to the main accumulation area. Therefore, the labels state the words "Laboratory Waste" as well as the contents of the container, and the hazard class (information which exceeds the requirements of MPC a).

The waste handlers also receive training specific to the management of laboratory waste at BC, as well as being required to provide BC with documentation of their training through their employer. They make rounds every week to pick up waste containers generated by lab workers. (MPC b, c, d) The waste containers in labs are in one of two states: *in use* (we call these "bench-top containers") or *in storage* (most of the containers in storage are full, though this practice

[1] In this report "laboratory" refers to the workspaces and workers under a particular Principal Investigator (PI) or supervisor. There may be multiple rooms associated with a single PI.

varies with department. The labs in the Biology Department are likely to keep containers in use in their waste storage area). The bench-top containers have labels and their own secondary containment. They may be located in fume hoods or in the main lab. Some bench-top bottles are fitted with an "Ecofunnel", which is a bottle fitting funnel with a built in cover. The containers in storage are capped, and are placed in secondary containment based on compatibility.

When the waste containers are delivered to the Main Accumulation Area (MAA) their labels are modified. The word "Hazardous" is added to the label as appropriate, and the date the waste arrives in the waste room is noted as the "Date to Main" (DTM). (MPC i)

Our management system has evolved to include a successful feature, the "Lab Safety Contact" (LSC), defined as the EHS point of contact in each laboratory. The responsibilities of the LSC include weekly inspection of the laboratory's waste accumulation area (MPC f), as well as distribution of information from the EHS Office. Information to the departments is channeled through the operations managers, to the PIs, the LSCs or all the lab workers as appropriate.

Boston College has been fortunate to have had no emergencies or events in labs that have resulted in releases outside the laboratory. However, we had an event in December, 2003 that tested our emergency management system, demonstrating the strengths of our emergency plan, as well as areas we have since targeted for improvement. (MPC g, h). There was a fire in a lab hood that resulted in structural damage confined to the hood and a release of water from a broken pipe. This event was managed by the Boston Fire Department and the EHS staff. Our communication system was able to notify EHS staff, department personnel and the lab's PI, with many of us responding within one hour. Members of the Department met with EHS staff and university administrators and devised and executed a plan to securely shut down laboratories and then to safely reoccupy them. EHS staff and Chemistry Department personnel also conducted an information session for the entire department, which was attended by approximately 80 people. The Chemistry Department solicited suggestions for additional fire prevention tools and training, and has awarded prizes for the six best ideas.

Performance Goals and Indicators[2]

<u>Management of Hazardous Chemicals of Concern (HCOC) (EPI's 1 and 2)</u>

We continue to have mixed success with chemical inventories and HCOC's. In the best case, we have a lab that conducts a chemical inventory and clean-out three times a year. In other cases we are provided a hand-written inventory. The initial HCOC inventory was completed in 2002 in conjunction with a total chemical inventory on paper, and was prepared by EHS staff who reviewed the chemical inventories. In the past year we have been examining options for achieving a centralized electronic chemical inventory, and have met with three vendors. Additionally, the Chemical Hygiene and Environmental Management Plan (CHEMP) Committee is discussing the option of developing an electronic database using standard data management tools (e.g. File Maker Pro) in lieu of purchasing a developed system. Our goal is to have a single electronic format for chemical inventories by the end of 2004 which can be used by EHS as well as the labs.

[2] In this report we are presenting the EPI's slightly out of order. It seems appropriate to move #8 to the last place because its subject is, in part, future goals.

We have pursued multiple strategies to reduce and effectively manage HCOC's in laboratories. First, in the course of standard hazardous waste management operations, when a special waste requires extraordinary resources, we use the HCOC inventory to identify similar material still being held in labs, and have been successful in getting labs to agree to dispose of those materials. This most recently resulted in the disposal of seven containers of picrates in a single high hazard disposal.

Second, we have linked the concept of HCOC's to performing risk assessments of experiments. In a recent training we discussed the steps involved in assessing experiments in the design phase, and we explained that the HCOC list can serve as a tool in identifying particularly hazardous chemicals.

We have had some difficulty in getting the labs to buy into the concept that HCOC's need to be managed with additional surveillance efforts. However, recent events in the labs (the December fire and a recent chemical spill) have created a more receptive environment which we intend to fully exploit. We will be meeting with each lab group in July and August to reintroduce the HCOC list and to request an assessment and disposal of unnecessary materials.

Pollution Prevention (P2) Activities (EPI's 3 & 4)

One successful P2 activity is currently in its final phase in the Chemistry Department. Over the last two years the organic chemistry teaching laboratory undertook a pilot chemical reduction program. Every time a chemical from the stock room was used, a red dot was placed on the container. After two years, most of the chemicals without red dots (meaning unused in two years) have been removed and more than 286 chemicals were made available to other lab workers for redistribution. Table 1 shows that 25% of solid chemicals and 31% of liquid chemicals were redistributed to other labs.

Table 1. Chemicals from teaching stockroom made available for reuse.

	Solid (Kg)	Liquid (L)
Available	47	16.76
Taken for reuse	11.9	5.25
% material redistributed	25	31

It is interesting to note that even when chemicals were identified as not being used in two years, there was some reluctance on the part of the teaching staff to release them to other labs. There is clearly a value seen by chemists in having some chemicals in reserve, or in not disposing of chemicals because they fear the replacement costs will be too high. Research and teaching are creative activities, and having a broad range of chemicals readily available is important to these activities. We continue to face the belief among chemists that most chemicals do not have a "shelf life." Given this, we encourage lab workers to dispose of chemicals on the HCOC list, and definitely emphasize those chemicals which deteriorate or present a significant physical hazard.

Hazardous Waste Generation (EPI 5)

Waste generation totals for the year 2003 were obtained from hazardous waste manifests. In previous years we used data from the waste-pick-up sheets submitted by laboratories. For consistency between years and the specific information available about the individual labs, this is the preferred method. However, some of the data (waste pick-up sheets) from 2003 were lost in our office move, so in this report we are providing a comparison of totals from manifests for 2002 and 2003.

Table 2. Boston College Hazardous Waste Totals (in pounds)

		2002	2003	Change
Chemistry Department	Bulk halogenated solvents	21435	15100	-29.6%
	Bulk non-halogenated solvents	12260	12405	+1%
	Bulk silica gel	2575	750	-71%
	Lab Packs	7102	9274	+30%
Biology, Physics, Psychology, Geology	Lab Packs	2094	1515	-28%
Totals		45466[3]	39044	
Chemistry waste as % of total		95%	96%	

There was a 14% decrease in the quantity of waste shipped from laboratories from 2002 to 2003. In previous years we reported as follows:

1999 – 2000	57% increase
2000 – 2001	3% decrease
2001 – 2002	no change
2002 – 2003 (current report)	14% decrease

The Chemistry Department continues to be the major producer of waste at Boston College (>95% lab waste shipped). In 2002, the ratio of non-halogenated bulk to halogenated bulk was .57. In 2003 this ratio rose to .82. This trend is indicative of the success of our training. We have a goal to reduce both the relative volume and total volume of halogenated solvent in order to increase the proportion of waste which can be used for fuels blending as opposed to incineration.

Environmental Awareness and Risk Reduction (EPI's 6 & 7)

[3] In the 2003 Project XL report we reported 34,735 lb of waste produced. In this report we report the 2002 result as 45,466 lb. This weight discrepancy results from the two different methods of calculating: in 2003 the weight was based solely on the contents of the containers, and would not have included any waste which was not reported on the waste sheets. In the current method (totaling weights given on the manifests) we are using the totals for contents PLUS the weights of all containers, including drums and the bottles contained within them. These totals also more accurately measure the amount shipped off site.

We made a few modifications to the Environmental Awareness Survey prior to distribution this year. (Appendix 1) Our goal was to increase our understanding of people's thoughts and attitudes about how they could personally influence the environment through their own behaviors. The questionnaire was distributed to all the attendees at Chemistry Department refresher training. We received 115 completed surveys, which is the best survey performance we have experienced during the Project.

In Table3 we show the comparison of % correct responses for nearly identical questions in both the 2003 and 2004 surveys. (The 2003 data are based on 34 surveys returned.) The results appear mixed. However, it is important to note that 25% of the responders in 2004 were undergraduates, many of whom have not had the same level of training as the traditional lab worker population.

Table 3: Comparison of responses to identical or comparable questions in Environmental Awareness Survey (% answers correct)

		2004	2003
The purpose of a fume hood is to protect		69%	44%
What is the proper way to dispose of strong mineral acids?		47%	65%
Ultimately, most chemical wastes generated in laboratories are:		96%	74%
In general, the cost of disposal of a chemical is ________ the cost of buying that chemical.	This question was modified in 2004.	68%	94%

The survey was redesigned to expose actual behaviors and attitudes of the respondents. Our first experience with this survey leaves us with many questions as well as answers, but perhaps a better idea of what lab workers are gaining from our training efforts. We make the following observations:

- Only 53% of lab workers reported using either a paper or online version of an MSDS for health and safety information. 21% consult a coworker. This suggests an opportunity for improving training to demonstrate the value of MSDS's.
- While 75% of respondents strongly agree that every lab worker is responsible for minimizing the impacts of their work on the environment, only 24% strongly agree that they are responsible when it comes to producing less hazardous waste. We need to find ways to transfer some of that responsibility from "others" to "self."

- In addition, they work in a culture where there is little exposure to information about pollution prevention in their field's publications. Only 19% agree with the statement "I have seen articles about pollution prevention in research in my discipline's journals."
- The survey suggests that there is reason to increase our efforts with Green Chemistry and Pollution Prevention, as 85% of respondents either agreed with or were neutral about the statement "It is important for scientists to find safer chemicals to use in their experiments."

While the questions and format of this year's survey offered some improvements over previous years, the Environmental Awareness Survey can be an even richer source of information in the future with a more careful design of the questions and analysis of the results. The present results point to additional program changes, such as improving access to undergraduates for training, better internal communication about pollution prevention opportunities, and improving training on MSDS's and hazard assessments.

We continue to enjoy the success of our training program. Each semester we offer initial training for all new lab workers. This entails three or four different training sessions to make them specific for departments and to allow for make-ups. In addition, we meet with the Chemistry Department once or twice a year for additional training opportunities. This past year we conducted training on fire safety, and refresher training covered risk assessments of experiments.

Table 4: Training Results

	# Trained		Topic	Date
	Initial	Refresher		
Biology	23		Chem Hyg & Env Mngmt (CHEMP)	Aug 03
Chemistry		125	CHEMP	June 03
	25		CHEMP	Aug 03
		81	Fire Safety	Mar 04
		129	Risk Assessment	June 04
Geology/ Geophysics	11	12	CHEMP	Aug, Sept 03
Physics	13		CHEMP	Nov 03
Psychology		2	CHEMP	Aug 03
Housekeeping	31		Chemical Safety Awareness	Jan 04

(CHEMP training is two hours. Fire Safety and Risk Assessment training are one hour. Training for Housekeeping lasted 45 minutes.)

Table 4a. Number of Training Contacts Made

Year	2000	2001	2002	2003	2004[4]
Lab workers	154	154	165	211	255
Custodial Staff, Science Buildings					31

[4] As of September 1, 2004.

The increases seen in 2003 (and the current year) are a result of two factors – need and access. We *needed* to add training sessions to address two unscheduled events, a methylene chloride excursion in our wastewater, and a fire in the Chemistry Department. While we wish these training sessions weren't necessary, the cooperation between the Chemistry Department and EH&S in developing new training and the *access* to the lab workers has resulted from the growing trust between our departments. We believe the growth in our training programs is a direct consequence of our experience with Project XL.

Compliance (EPI 9)

Audit results (Appendix 2) showed slight increases in scores from 2002 to 2003 for some of the departments.

Table 5: Audit Summary - Average Scores out of 10 points

	2002	2003
Biology	5.1	7.2
Chemistry	8.5	8.6
Geology	9	10
Physics	4	insufficient data

Given that the Chemistry Department produces 96% of the waste generated by laboratories, a much larger effort is devoted to management of the program for that department. It is apparent that the increased attention pays off, as Chemistry continues to have the best scores from the lab waste area audits. EHS has assigned one member of the Office to be the primary contact for Chemistry, and this relationship has paid off in terms of improved compliance. The Biology Department has improved considerably, most likely due to the improved cooperation of the department in getting people to attend training. Physics is increasing its use of chemicals in the laboratories, and our training program will be expanded accordingly.

Objectives and Targets (EPI #8)

While we did not clearly spell out future objectives and targets in our last report, we believe we have accomplished the following in the spirit of improving our environmental management system and our contribution to Project XL.

- During the past year we have been successful in reducing the amount and proportion of halogenated waste produced by the research labs, resulting in a total waste reduction of 14%.
- We more than doubled the amount of time spent in training opportunities in the Chemistry Department. This included formal training sessions and on the spot training during lab inspections and building visits.
- We have developed a stronger relationship with the Chemistry Department's Safety Committee, attending more of their meetings, working with them to create better Standard Operating Procedures, and improving communication between EHS and the Department.

Objectives for the next year (2004-05):

- Increase the amount of training provided to undergraduates in research laboratories.

- Work with the departments in completing an updated electronic chemical inventory (either a total inventory or HCOC inventory.) Use the inventory as a driver for disposal of unneeded chemicals.
- Work with the Physics Department to provide adequate training for the increasing chemical activities in their labs.
- Review the Environmental Management Plan with the Chemical Hygiene Committee, and assess the value of incorporating the EMP into the Chemical Hygiene Plan.

<u>Conclusion</u>

We are happy to provide the results of our ongoing pilot program in the management of laboratory wastes at universities. Boston College is very proud to be a contributor to the current national conversations about university waste management.

We are also pleased to report a 14% decrease in the amount of waste we have produced, though without proven normalization measures we cannot be sure how much of the decrease is due to the Environmental Management Plan vs. the random and non-random changes that occur in university research programs.

We continue to be challenged by the complex organizational environment of the research university setting. Behaviors and attitudes are changing, though more slowly than we would like given our investment of time and resources. Our redesigned Environmental Awareness survey suggests we are moving in the right direction, but also demonstrates that we have more work to do.

Boston College looks forward to the next two years of work with EPA and our partner schools.

Appendix 1: Environmental Awareness Survey Result

Question Number		# *responses*	*% responding*
1	When I need health/safety information about a chemical I consult (check the two most common sources):		
	__an appropriate MSDS *on line*	84	0.40
	__an appropriate MSDS *paper copy*	28	0.13
	__the Merck Manual	24	0.11
	__a Hazardous Chemicals Desk Reference	9	0.04
	__My lab supervisor	20	0.10
	__A lab colleague	44	0.21
	__Other (specify)______________________ copy room	1	0.00
	Total # Responses	**210**	
2	Which of these factors do you think is the largest overall environmental impact of laboratory work:		
	a. Use of toxic chemicals	30	0.24
	b. Utility use (energy and water)	14	0.11
	c. Hazardous waste production	80	0.64
	d. Biomedical/sharps waste production	2	0.02
	e. Animal waste production	0	0.00
	Total # Responses	**126**	
3	Which of the following are the top two environmental impacts of *your* research?		
	a. Use of toxic chemicals	69	0.35
	b. Utility use (energy and water)	29	0.15
	c. Hazardous waste production	89	0.45
	d. Biomedical/sharps waste production	11	0.06
	e. Animal waste production	0	0.00
	Total # Responses	**198**	
4	The purpose of a fume hood is to protect (pick the most important answer as it applies to your work):		
	a. The laboratory worker	86	0.70

	b. Equipment in the laboratory	1	0.01
	c. The laboratory building and its occupants	29	0.24
	d. The outside environment	7	0.06
	Total # Responses	**123**	
5	What is the proper way to dispose of strong mineral acids?		
	a. Dilution with water	17	0.15
	b. Neutralization with lime	37	0.34
	c. Collection for pick-up by hazardous waste personnel	57	0.52
	d. Mixing with organic chemicals	2	0.02
	Total # Responses	**113**	
6	Ultimately, most chemical wastes generated in laboratories are:		
	a. incinerated	52	0.45
	b. sent to a landfill	5	0.04
	c. release to a sewer	3	0.03
	d. treated	57	0.49
	Total # Responses	**117**	
7	In general, the cost of disposal of a chemical is ______ the cost of buying that chemical.		
	a. Less than	15	0.13
	b. Equal to	21	0.18
	c. A little more (less than twice as much)	30	0.26
	d. A lot more (more than twice as much)	49	0.43
	Total # Responses	**115**	
8	In general, how are fume hood emissions treated before being released to the environment?		
	a. Filtration to remove particles	29	0.25
	b. Carbon filtration to remove gases	30	0.26
	c. Dilution with laboratory room air	16	0.14
	d. Scrubbing to remove particulates, gases and toxics	40	0.35
	Total # Responses	**115**	

Please rate on a scale of 1-5 with 1 being Strongly Agree and 5 being Strongly Disagree. If Not Applicable write NA

		1	2	3	4	5	NA	Total #
9	It is the responsibility of every lab worker to minimize the environmental impact of their work.	80	14	6	3	10	0	113
	% responding	75%	13%	6%	3%	9%	0%	
10	With careful planning, I would be able to produce 10% less laboratory waste without affecting my research output.	27	32	24	15	12	3	113
	% responding	24%	28%	21%	13%	11%	3%	
11	Hazardous waste is a necessary byproduct of chemical research.	46	24	28	4	11	0	113
	% responding	38%	20%	23%	3%	9%	0%	
12	It is important for scientists to find safer chemicals to use in their experiments.	36	35	25	10	7	0	113
	% responding	32%	32%	23%	9%	6%	0%	

#	Statement	1	2	3	4	5	NA	Total #
13	It is not my responsibility to make changes in the way my research is done in order to produce less hazardous waste.	4	17	18	35	34	5	113
	% responding	3%	15%	15%	30%	29%	4%	
14	I have seen articles about pollution prevention in research in my discipline's journals.	9	15	18	25	28	18	113
	% responding	7%	12%	15%	21%	23%	15%	
15	I routinely review the health and safety information on the chemicals I use.	6	33	38	28	8	0	113
	% responding	6%	30%	35%	26%	7%	0%	

16 Please check the types of laboratory worker training you have received at Boston College

__ Chemical Safety	102
__ Laboratory Waste Management	66
__ Radiation Safety	13
__ Biosafety	11
__ Laser Safety	8
__ Other (specify) ____________________________________	0

17	What is your current role in your laboratory?		
	[ ] Faculty	1	0.94%
	[ ] Staff	10	9.43%
	[ ] Graduate Student	67	63.21%
	[ ] Undergraduate Student	28	26.42%
		106	
18	How long have you been working in a Boston College lab?		
	[ ] less than 1 year	40	37%
	[ ] 1-2 years	34	32%
	[ ] 3-5 years	32	30%
	[ ] more than 5 years	0	0%
		106	
19	Have you completed an XL Environmental Awareness Survey in the past?		
	[ ] Yes	26	
	[ ] No	79	

Appendix 2: Audit Scores

Room[5]	LWAA # container	LWAA # compliant	Bench Top # containers	Bench Top # compliant	Container management /4	SOP /4	Self Inspection /2	Grade /10
Chemistry Department								
101	10	9	0	0	3	3	1	7
102	0	0	6	6	4	4	2	10
103	3	3	0	0	4	4	1	9
104	0	0	9	8	3	3	2	8
105	3	3	1	1	4	4	2	10
106	5	5	0	0	4	4	2	10
107	7	7	0	0	4	4	2	10
108	15	12	0	0	3	2	0	5
109	0	0	0	0	NA	3	2	
110	3	3	5	5	4	4	1	9
111	3	3	8	8	4	4	2	10
112	10	8	4	4	3	4	2	9
113	3	3	6	5	3	3	0	6
114	4	4	5	3	3	3	2	8
115	5	5	11	10	3	4	2	9
116	6	6	6	6	4	4	0	8
117	3	3	8	8	4	4	2	10
Average Score								8.625
Physics Department								
301	0	0	0	0				
Average Score								NA
Biology Department								
201	4	4	0	0	4	4	0	8
202	14	12	0	0	3	3	2	8
203	3	3	0	0	4	4	2	10
204	0	0	0	0	NA	4	2	
205	1	0	0	0	2	3	0	5
206	0	0	0	0	NA			
207	7	7	0	0	4	3	2	9
208	4	4	0	0	4	3	1	8
209	9	3	0	0	1	2	0	3
210	9	8	0	0	3	3	0	6
211	5	4	0	0	3	3	2	8
212	0	0	0	0	NA	2	NA	
Average Score								7.222222
Geology								
401	1	1	0	0	4	4	2	10
402	0	0	0	0	NA			
Average Score								10

[5] The room numbers have been coded for the purposes of the publication of this report.