Boston College
Project XL Report, 2003

Introduction

This report presents the results for the year 2002 for Boston College (BC) laboratories under the New England University Laboratory Project XL (henceforth referred to as Project XL or the Project.). An annual report provides the participants the opportunity to reflect on and evaluate our performance to date. With three years of experience under our belts, we are also in a better position to know what has worked and not worked for us[1]. This report will discuss the Environmental Management Plan experience at BC in terms of the Environmental Performance Indicators (EPIs) laid out in the Final Project Agreement (FPA). Waste data represent activities for the calendar year 2002. Other activities and data represent the Boston College fiscal and academic year, 2002-03.

Environmental Performance Indicators

Outdated Chemicals on the Shelf and Hazardous Chemicals of Concern (EPI #1 and #2)

The history of HCOCs at Boston College has put us approximately a year behind the two other XL participants. In 2000 we equated total chemical inventories with meeting the HCOC requirement of Project XL. Feedback from our EPA partners was that this interpretation was not adequate to meet the requirements of XL. Therefore, in 2001 we developed an HCOC sub-inventory, conducted a physical inventory of high hazard chemicals (explosives, reactives), and reviewed the total inventories submitted by the labs for chemicals on the HCOC list. No data were recorded from the inventory review. In 2002, we again reviewed the latest completed inventories, and recorded data as to number of HCOCs found, types of HCOCs and specific hazards. This information is described, by department, in Table 1.

Table 1: Hazardous Chemicals of Concern

Department	# Labs*	#HCOC's	# Chem
Biology	18	65	4243
Chemistry	15	555	17411
Geology	2	11	118
Physics	5	17	302
Psychology	2	3	108
Total	42	651	22182

* Only labs where chemicals are used are included.

After working through the HCOC process for two full cycles, we have identified the following issues and recommendations.

1. Our labs are still required to complete full annual chemical inventories to meet state and local emergency response requirements. A selective inventory of high hazards is not an acceptable substitute to the local fire departments. Therefore, EH&S will continue to assist the labs in monitoring HCOCs by (a) reviewing the full inventories, and (b) providing labs with a tailored list of HCOCs which they should evaluate for shelf life and future use.

[1] The reader is advised that this report varies from previous ones in that the author has been studying the Project XL experience for a personal project in an MBA program. While every attempt has been made to keep the formats and findings consistent with previous years, it is impossible to fully isolate the reporting of XL for EPA and other stakeholders from findings and opinions formed in the other context.

2. The Boston College HCOC list was compiled from a variety of sources.[2] After two years of experience we have found 115 of the 256 designated HCOCs at BC. There are also some very hazardous chemicals in our complete inventories that were not found on any of the source lists and were not designated as HCOCs. There is a need to review the current HCOC list and add and subtract as necessary to reflect the specific holdings of BC's labs.
3. A central electronic inventory would provide vast improvement in how we manage our inventories and flag chemicals for particular hazards. EH&S and the science departments are currently examining a number of different chemical information management systems and we hope to secure support and funding to purchase a system in the near future.

We believe that the concept of HCOC management as developed in the Project XL is a very useful risk assessment tool. It has allowed us to identify labs where additional concern is warranted, as well as labs where a single chemical is designated an HCOC. While not ignoring those low risk areas, we can work towards better management of the chemical risks in the higher hazard areas.

Pollution Prevention (EPI #3, #4)

Boston College conducted specific P2 activities directed at more easily attainable targets prior to and since the start of Project XL, attempted a chemical redistribution program during Years 2 and 3, and hosted a Pollution Prevention / Green Chemistry Workshop in November 2003. These efforts have met with varying degrees of success.

- A mercury thermometer exchange and training were successful in eliminating mercury contamination in drains and wastewater.[3]
- Labs which use chromic acid based cleaners were trained in reduction and re-use; the volume of chromic acid cleaner waste we receive is small (<20 lb/year).
- In 2002 a lab in Chemistry stopped using a cleaner, aqua regia (mixture of hydrochloric acid and nitric acid), because of its reactivity hazard.
- Chemistry lab workers reuse acetone for glassware rinsing until it becomes saturated.

These efforts have produced small reductions in the quantity of hazardous waste generated and disposed.

We also tackled the challenge of chemical redistribution and learned the following lessons:

- BC has a relatively stable lab population, so clean-outs of labs are rare. Previous clean-outs have been the major source of orphaned chemicals. (In 2002, with no lab clean-outs, we collected 25 containers of unused chemicals, for a total of 35 lbs. Most of these chemicals were not reusable.)
- When a clean-out occurs, it is often an older lab where the chemicals are not desirable for re-use.
- The most common form of chemical redistribution continues to be informal, intra- and inter-lab borrowing, where the chemical's owner is known and presumably trusted.
- The BC Chemistry Department's current management practice (decentralized purchase and storage at the level of individual graduate students) promotes redundancy in chemicals purchased and stored. This issue is being addressed by EH&S, the departments, and the administration.
- In order for BC to manage a program of chemical redistribution we would need the following:
    - A reliable source of "used" chemicals (supply)
    - A system of documentation.(administration)
    - Location.
    - Personnel.

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[2] HCOC list compiled from Prudent Practices in the Laboratory, list of carcinogens, peroxide formers, explosives, acute toxins, oxidizers, DOT poison-by inhalation, and frequently found P-listed chemicals. For additional details, see BC Project XL Report, May 2002

[3] From 2002 sampling of lab drains and semiannual MWRA reports

Due to lack of supply, demand, and resources we do not intend to work on a formalized redistribution system, but rather hope to implement an electronic inventory system to provide better management of chemical inventories and to decrease the number of redundant or surplus chemicals.

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Thus far, our P2 efforts have had effects on such a small percentage of our total waste generated that any improvements have been undetectable. As important to our efforts at Pollution Prevention has been gaining a deeper understanding of the specifics of waste generation so as to develop better P2 targets. The Chemistry Department produces 96% of the waste at BC, and 15% of the Chemistry research labs produce 80% of the waste. P2 efforts need to target the 80% in order for us to show measurable and meaningful improvement.

In November 2002, Boston College hosted a Pollution Prevention Workshop in order to learn more about pollution prevention. This meeting brought together students and scientists from academia and industry, chemical and waste management vendors, and members of the regulatory community from both federal and state levels.[4]

One question that framed the concept of the workshop was how to make changes in the areas where our waste production has such a strong impact, i.e., those research areas that are intense users and generators of solvents. One of the major themes of the workshop was that Pollution Prevention, such as the use of less material or chemical substitution, must be incorporated into the experimental design. This is a concept that can be continually put forward as a challenge to researchers as they plan their future work, but the fruits of such thinking will take time and considerable nurturing. In fact, according to a study presented at the P2 workshop, there are not yet P2 incentives in place in the granting process.[5] DOE has a requirement that grant recipients show they will not negatively impact the environment in the course of their work, although this requirement does not specifically consider Pollution Prevention. Most other grants don't go as far as DOE.

In addition, the culture in which scientific research is performed is a very traditional one, where new research is based on previous work. Therefore, it is difficult to insert Green Chemistry concepts such as chemical substitution or reduction or process change or new experimental design into a system where validity is based on repetition, not innovation. It will take more than the efforts of EH&S personnel in a pilot project to have a significant impact in waste reduction at universities, but we have certainly provided a context for the conversation to begin and will continue to advance it both internally and through our professional associations.[6]

Waste Totals (EPI #5)

The two main activities related to our waste reduction goals were to continue to increase education about P2 in training, and to continue to analyze the sources of waste to identify other opportunities for reduction. The waste totals for the four years of the Project XL are given in Table 2. In 2002 BC produced 400 more pounds of laboratory waste than in 2001 (1% increase) and the Chemistry Department produced only 28 more pounds (0% increase). Because we have yet to find a way to normalize waste volumes against research dollars, personnel, subdiscipline, or other possible measures, we cannot state unequivocally that we have succeeded or failed.

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[4] Flier attached, Appendix C
[5] Presentation by Sapna Thottathil, EPA intern, at P2 Workshop, 11/12/02.
[6] Two presentations are currently scheduled for summer 2003. Additional publication under consideration.

Throughout the span of the project Chemistry has accounted for 96% of the waste volume (Figure 1), so most of this discussion will focus on Chemistry. However, Biology showed a 60% increase over last year, and it is worth noting a couple of factors that may have contributed to that increase (below).

Table 2: Annual Hazardous Waste Totals

	Weight (lbs.)			
Department	**1999**	**2000**	**2001**	**2002**
Biology	1199	952	808	1287
Chemistry	21598	35642	33363	33391
Geology	23	24	85	(a)
Physics	N/A	46	25	46
Psychology	391	100	54	11
Total	23211	36764	34335	34735

(a) Data not recorded, but estimated at ~ 80 lb.

In our 2002 report, I hypothesized that an increase in research activities was causing the unexpected increase in waste volume over the baseline figures. At the time, I tried to normalize against research dollars and personnel, and found that neither of these factors provided a reliable way to connect research activity and waste production. The most meaningful observation was that waste volume varied by subdiscipline, and within a subdiscipline like organic synthesis it might then be possible to normalize against personnel, square feet or research dollars.

By looking at the waste trends per lab[7] within a subdiscipline, it appears that another important factor in predicting waste production may be maturity of the research program. Of the six labs that produce the majority of our hazardous waste, labs where the Principle Investigator (PI) is on tenure track show major increases in waste production, while labs where the PI has secured tenure and has been conducting research for a number of years show a stabilization or even decrease in waste production.

In terms of the academic culture, it makes sense that investigators who are seeking tenure will need to produce papers, and if their research requires it, hazardous waste. The new PI starts with a few graduate

[7] Here a lab is defined as a group of workers in a contiguous space under the supervision and sponsorship of a Principle Investigator (PI).

students. As she becomes more established, the numbers increase. In years 3, 4, and 5, requirements for reappointment and promotion to Associate Professor mean that there is a heavy push to publish, i.e. to do experiments, i.e. to produce waste. This can be seen for two labs in Chemistry where the PI's are tenure track, (Table 3, PI numbers 7 and 10). In both cases the physical space of the labs has grown, and the number of graduate students working in the lab has increased. There is a positive feedback loop where more success at getting grants means more people, space and equipment means more waste and more papers and better chances of getting tenure.

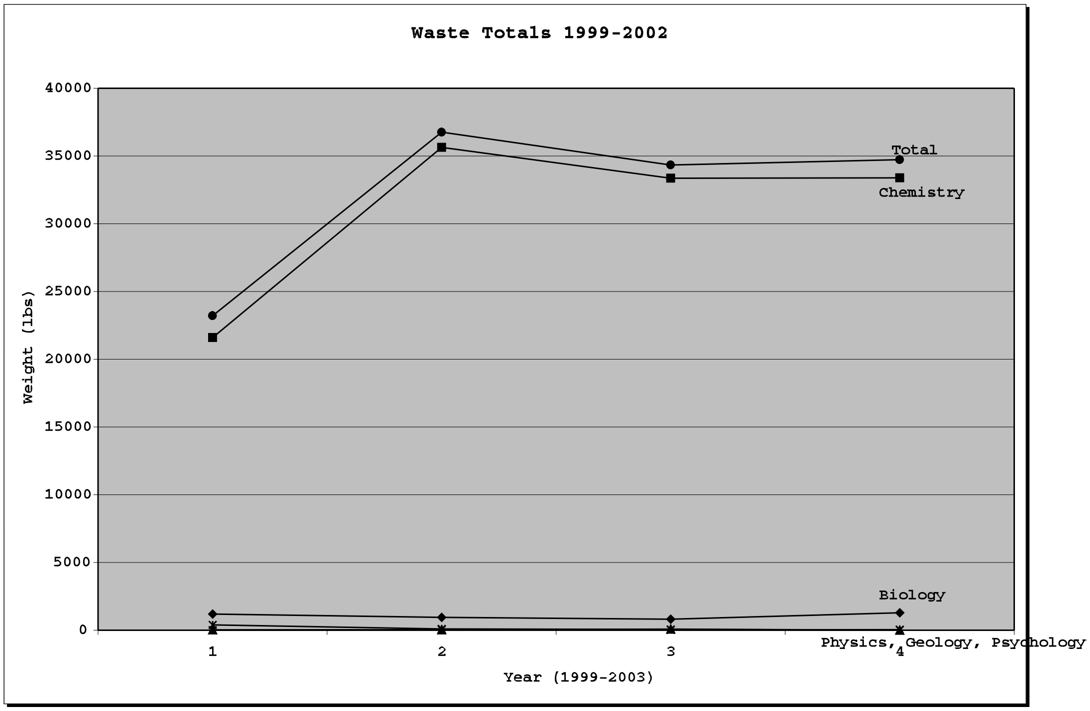
Table 3. Waste Totals by PI

On the other hand, there was a 10% decrease in waste produced by the largest lab group, PI 5, and reductions seen in other "mature" labs (PI's 3, 4, 12 and 13). PI's 1& 2 and 11 are labs which have had clean-outs in 2002, hence the increases over last year.

It is interesting to note that in the Biology Department (Table 2), which showed a 60% increase in waste production in the past year (still only 4% of our total lab waste generated), two members of the faculty were submitting files for promotion and tenure in 2002.

This year's data provide us with additional insight for developing normalization criteria, such as career "age." While a waste production of zero is the absolute ideal, in reality there will be some waste produced as a side effect of doing scientific research and teaching. Given that, the challenge remains to identify particular opportunities to reduce waste amounts, and to measure those reductions in ways that stand out despite other variables in the waste production equation.

Figure 1: Waste Totals by Department



Environmental Awareness (EPI#6)

We issued the same Environmental Survey to lab workers as in previous years. We distributed 275 surveys to the science departments on 6/3/03. As of 6/10/03, 34 surveys have been returned (15%). (Additional results will be compiled and submitted as an addendum to this report). All respondents were entered in a raffle to win one of six gift certificates valued at $10 to $25.

Both the number of returns and the scores for the survey are informative of future work that needs to be done. Survey returns are important to the process of learning from the Project. If we choose a labor intensive method of distributing surveys (e.g. personally delivering and collecting) we have higher numbers of returns. With the availability of a student worker only starting on June 2, I was forced to use the less reliable method of distributing to mail boxes. However, we included a pre-addressed return envelope to make it easy for recipients, and the raffle incentives to encourage returns (increasing the number of prizes to provide greater odds of winning). Given the return of 34 surveys in a week, it seems that conducting an assessment of lab workers' environmental awareness in its current format continues to be a challenge.

We know from lab audits that we have been successful with the portion of training that focuses on container management. The surveys also support this. What seems to be missing according to the surveys (both numbers of responses and scores) are interest in environmental awareness and a true appreciation of the environmental impacts of lab work. However, the lab workers should not be faulted for this performance. Our training and communication programs have focused primarily on specific compliance requirements, because those are the criteria on which we inspect and are inspected. We have not created an adequate educational component to cover the more theoretical issues.

Conducting a survey is an important part of the toolbox EH&S needs to use to work with labs in developing both compliant practice and improving environmental awareness. However, the survey that we have used for the past three years is very limited in scope, and not adapted for the programs at each of the schools. If the Project is extended, a different approach to surveys may prove more valuable to all of the stakeholders.

Table 4. Environmental Awareness Survey Results

Training (EPI #7)

In 2002 we trained 165 people in the EMP and waste management. We reached all new graduate students, post-doctoral fellows and faculty. Most of the Chemistry Department also reported for an annual refresher, and also attended a training on management of methylene chloride waste (related to an MWRA issue; data not included).

Table 5: Training Data

Training is a component of the EMP that we feel has a strong system in place, and we are seeing an increase in numbers trained as a result. We are assisted in training coordination by administrators in each of the departments (except Psychology, where the population is small enough that they manage themselves). The administrators identify all new workers at the start of the year, and those people receive initial training. In the Chemistry Department we are also invited to conduct annual refresher training. The Geology Department has a stronger requirement: only people who have been trained will have access to the chemistry labs.

In addition, EH&S is able to request department meetings to discuss specific issues that might arise. We had approximately 120 people in Chemistry attend a special training on the management of aqueous waste containing methylene chloride in November, 2002.

Each department has shown their commitment to get lab workers trained and has provided the coordination support necessary. We will continue to conduct training of these groups, and plan to begin a training program for undergraduates doing research.

Objectives and Targets (EPI #8)

Our objectives and targets for the Year 2002 were:

1. Analyze waste generation in order to understand past increases and predict future trends.

Result: We have increased our understanding of BC's waste generation patterns. Department growth continues to be a major challenge as we try to reduce our waste volumes.

2. Determine normalization criteria to allow for calculating waste totals that reflect both waste minimization activities and the other factors that influence waste totals.

Result: We continue to add to our list of factors that make bottom line waste numbers incomplete indicators of waste activities. In the past we determined that the type of research done was a strong indicator of waste volume produced. This year we have identified phases of laboratory “life cycle” that may influence waste production rates. Other normalizing factors we have attempted to use without success to date are number of people and amount of research dollars. We will continue to try to develop a normalizing equation so that waste comparisons from year to year or between schools will be meaningful indicators of waste minimization success.

3. Identify particular waste streams for targeted reduction.

Result: We have collected data on all wastes generated by labs. These data have indicated the following areas where we can continue to pursue waste minimization:

- Acetone recycling: Acetone used in rinsing glassware can be separated from other solvents and then recycled, either in house or by a vendor.
  - Status: Currently there is not a vendor that can manage the relatively small quantities of acetone that labs generate. In order to recycle acetone in house we have to overcome the following hurdles – purchase of solvent distillation equipment; permitting by local Fire Department and Massachusetts Department of Environmental Protection; identifying users for recycled product; location for equipment and personnel to manage.
- Solvent use reduction: Eighty-five percent of our waste stream is solvents, approximately 50% bulked halogenated mixtures and 50% bulked non-halogenated.
  - Status: Better segregation of halogenated solvents would allow for more waste being diverted to fuels blending. While this is not technically waste reduction, it is a preferable technology to incineration because of the energy value derived from the process. Since the beginning of XL we have achieved a shift from 25% to 50% solvents for fuels blending. We will continue to work on improving segregation of solvents.
- Introduction of Green Chemistry concepts: The P2 Workshop hosted at BC brought two speakers who are actively working in Green Chemistry to our campus. The Chairs and managers of Chemistry and Biology attended the workshop, as well as some BC faculty members and students, one of whom won an EPA Green Chemistry award.
  - Status: As part of overall improvements to our EH&S and Project XL web sites, we will develop a Green Chemistry information section and web link. We will also be hosting a second Green Chemistry Workshop at BC in January, 2004. The marketing focus of this workshop will be toward graduate students, especially BC students.
  - One researcher, Scott J. Miller in Chemistry, has seen some success in developing non-solvent based synthesis reactions, and his graduate student, Bianca Sculimbrene, won an award from EPA for this work.

Laboratory Audits (EPI #9)

We succeeded in completing three out of four rounds of our quarterly audits in the past year. In order to get a better “grading system,” the most recent audit (Winter/Spring 2003) included information about the number of containers seen in the labs and number of containers found not in compliance. We also classified the containers as “benchtop” or Lab Waste Accumulation Area (LWAA). (Appendices A & B)

Table 6: Audit Results

The audit data are suggestive of the following:

1. The Chemistry Department shows the best performance in container management, and a high overall compliance score. Because Chemistry has the greatest volumes of chemicals, the most

HCOCs, and produce 95% of the lab-generated waste, we have focused our efforts there, and our success is apparent in the scores.

2. The Geology Department has a small number of chemicals and an active administrator. Training by EH&S and reinforcement by the administrator have had a positive impact on performance.

3. Biology is the Department with the second largest number of chemicals. Prior to the employment of the Operations Manager for the Higgins Building, it was more difficult to organize training. The lab workers also perceive themselves to be at lower risk, so their incentive for compliance is not as high as those who work in Chemistry. This is a department that deserves greater attention in the future.

4. Physics has the fewest chemicals, and the fewest people using them. Compliance with container management is handled on a one-on-one basis when we do waste pick-ups. Other issues need to be addressed in training. Given the number of people who use chemicals in the Physics Department, this process may be more effective with personalized training.

Conclusion

As in previous years, this annual report reveals some successes and some ongoing challenges.

- We have yet to find a way to account for both our waste minimization efforts and the University's growth activities in a way that shows a reduction in the waste bottom line. Normalization criteria are important factors that we will continue to identify and attempt to track.
- We have continued a strong training effort and seen some improvements as measured by compliance and Environmental Awareness, but we have yet to achieve 100%, enthusiastic commitment to the Environmental Management Plan.
- We have a better sense of which labs pose unusual risks because of the chemicals they store, and we can focus our training efforts first on those labs.
- The congenial relationship between EH&S and the lab personnel grows. There is more sharing of information, and a much diminished sense of "us and them" when we visit the labs. In other words, there is a definite partnership between us.

In general, the New England University Labs Project XL has had a significant and positive impact on Boston College. We know that there is a tremendous amount of work that remains to be done. If we are granted an extension, then we will be able to continue on this course and we hope contribute more information and tools to help other universities improve their waste management programs.

Report prepared by N. Gail Hall, M.S., CHMM, June 7, 2003

Appendix A: Audit Scores

	LWAA		Bench Top		Cont. Mgmt	SOP	Self Inspection	Grade
ROOM	# cont	# comp	# cont.	# comp	/4	/4	/2	/10
Geology Department								
D021	2	1	0	0	2	4	2	8
D319	1	1	3	3	4	4	2	10
Avg. Score								9
Physics Department								
H110	3	3	0	0	4	2	0	6
H120	0	0	0	0	N/A	2	0	2
H150	1	1	0	0	4	1	0	5
H160	1	0	0	0	2	1	0	3
Avg. Score								4
Biology Department								
H375	2	1	0	0	2	2	0	4
H430	2	2	0	0	4	2	4	10
H430	3	0	1	0	1	2	2	5
H480	0	0	4	0	0	4	0	4
H490	0	0	0	0	N/A	4	2	6
H500	5	2	0	0	1	2	0	3
H510	17	17	8	7	3	4	2	9
H520	2	1	0	0	1	2	0	3
H530	0	0	0	0	N/A	4	0	4
H544C	1	0	0	0	3.5	4	0	7.5
H560	10	7	0	0	2	2	0	4
H580	2	2	0	0	4	4	0	8
H590	0	0	0	0	N/A	4	0	4
Avg. Score								5.1
Chemistry Department								
M006	6	6	0	0	4	1	2	7
M008	11	11	1	1	4	4	2	10
M105	0	0	0	0	N/A	1	N/A	1
M209	2	2	0	0	4	4	2	10
M210	4	4	1	1	4	2	2	8
M227	9	9	1	1	4	4	2	10
M227	5	4	0	0	3	4	1	8
M231	8	8	0	0	4	4	2	10
M236	8	8	8	3	2	4	2	8
M243	10	9	1	0	2	4	2	8
M246	0	0	6	6	4	4	2	10
M309	5	5	15	11	2.5	4	1	7.5
M315	10	9	5	5	3	4	2	9
M321	12	12	7	5	2.5	4	2	8.5
M325	12	12	10	7	3	4	2	9
M331	5	5	10	9	3.5	4	2	9.5
M337C	0	0	7	6	3	4	2	9
M337E	1	1	7	6	3	4	2	9

M339	6	6	7	7	4	4	2	10
Avg. Score								8.5
Average for all Departments								7.0

Appendix B: Sample Audit Checklist

Laboratory Waste Area Inspection Checklist

Building / Room_____________Department_________________PI_________________________ _______

Inspected by____________________________________Date_______________________

	Yes/No	Comment
All lab workers are aware of laboratory waste and chemical hygiene policies and procedures.		
Laboratory waste bottles are labeled.		
All labels are filled out properly and completely.		
Secondary containment is being used.		
Lab waste accumulation below 55 gallons.		
Lab waste accumulation for acutely hazardous waste below 1L (1 Kg)		
Once a container is full it is removed within 30 days.		
Waste containers are closed.		
Containers are in good condition, not leaking, and segregated from incompatible wastes.		
Containers are compatible with their contents.		
The weekly Waste Inspection Sheet is up-to-date.		
Area is free of spills or releases of laboratory waste.		
In-line (automated) waste collection meets requirements of EMP		
Spill response equipment is available.		
Emergency contact information and notification procedures are posted.		
Signs locating eyewashes and showers are visible.		
Evacuation procedures are posted.		
PPE is available and used appropriately by lab workers.		
Engineering controls (e.g. fume hoods) are used appropriately.		

containers in LWAA_______________# problems seen______________
benchtop waste containers_________________# problems seen______________
Comments:

Appendix C: Excerpt from P2 Workshop Brochure

OVERVIEW

This workshop is designed to gather ideas about Pollution Prevention (P2) and Green Chemistry practices for teaching and research and to generate discussion among the many stakeholder groups. Researchers will discuss successes and challenges in developing Green Chemistry methods. The regulated community and the regulators will have an opportunity to discuss the factors that are currently in place as well as those needed for future development of P2 activities in labs.

There will be a poster and vendor display area at the workshop where the intent is to demonstrate and share successful technologies, techniques and approaches that reduce or eliminate the use or generation of hazardous substances in the laboratory. We expect about 30 posters and displays from vendors, researchers, students and government agencies.

The workshop will culminate with the identification and cataloging of P2 ideas and practices that will be shared with participants plus a discussion of future steps.

Audience:
EH&S professionals; Laboratory supervisors and workers; Agency stakeholders. We expect approximately 100 participants.

Sponsors:
University Laboratory Project XL Institutions:
- Boston College, University of Massachusetts, Boston, University of Vermont

Campus Consortium for Environmental Excellence
Environmental Protection Agency, New England
Massachusetts Department of Environmental Protection
American Chemical Society, Division of Chemical Health & Safety
Vermont Agency of Natural Resources

AGENDA

8:00 **Registration/Breakfast**

9:00 **Welcome:**
Keith Kidd, Acting Director, EH&S, BC
Tom Devine, Vice President, Facilities Management, BC

9:20 *Green Chemistry Panel*
What is Green Chemistry, John Warner, Ph.D, UMB
Green Chemistry in Research and Teaching, Scott Gordon, Ph.D, UVM

10:15 *Break*

10:30 *Different Perspectives on P2 in the Laboratory:*
Industry R&D Perspective, Joanna Negri, Ph.D., Pfizer
Connecting Health & Safety with Pollution Prevention, Ralph Stuart, UVM
EPA's Perspective, Josh Secunda, EPA

11:30 *Poster Session*
Buffet Lunch

1:00 *Green Chemistry at UMass Boston: Experience from the laboratory, classroom and Project XL*
John Warner, Ph.D.

1:30 *Promoting Institutional Change to Achieve P2/GC Goals, Franklyn Daley, Wyeth Pharmaceuticals*
EPA Evaluation of granting organizations Sapna Thottathil, EPA Summer Intern
Reducing mercury discharges from laboratories, Kevin McManus, EBI

2:30 *P2 Best in Show Awards*
Participant feedback
Next Steps, Gail Hall, EHS Officer, BC; Thomas Balf, C2E2

3:30 *ADJOURN*

For more Information, please contact:

Poster Submission

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Directions:

For directions to Boston College and i on parking, please check our website a www.bc.edu/ehs