Annual Report on Project XL Activities at Boston College

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Introduction

This report contains the findings and observations of the most recent year of Boston College's participation in the New England College and University Laboratories Project XL. The report includes waste data for the calendar year 2004, and survey, training and other data for the academic year 2004-2005.

Management of Hazardous Chemicals of Concern (EPIs 1 & 2)

Laboratories are required to submit complete chemical inventories to the Office of Environmental Health and Safety annually. These inventories are used by us to meet regulatory requirements, including emergency planning, Tier II and emission source registration reporting. We compare the HCOC list to the main inventory in order to identify HCOCs in various locations in labs. The HCOC list is also used to identify particular chemicals for targeted clean-out or maintenance (e.g. ethers, picric acid). In the past year we have used the HCOC list in developing a protocol for limiting lab activities when there is a significant event on campus[1] (e.g. football game, commencement, Boston Marathon). By sorting the HCOC list based on certain parameters (e.g. Class 1A flammables [Table 1] and reactive chemicals [Table 2]), we have been able to provide labs with a discrete list of chemicals whose use is prohibited during significant events when there are large numbers of people on campus and emergency response to campus is difficult. In addition, the HCOC table is used to provide information on chemical storage of unstable chemicals.

[1] The Merkert Chemistry Center is adjacent to the sports complex on the south west side. Higgins Hall, housing the Biology and Physics Departments, is adjacent on the north side. The sports complex includes a 45,000 seat stadium and an 8,000 seat sports arena.

Table 1: HCOCs sorted by NFPA Diamond Flammable Level 4 (Lab workers are prohibited from using these chemicals during significant events.)

CHEMICAL:	HCOC Reactive [R]/ Toxic [T]	NFPA Flammability Rating***	Oxidant [S/L/G]	Explosive	Peroxide Former Class**	Acute Toxicity: DOT Poison*	Waste Code***	Special Handling Requirements
Acetaldehyde	**R**	4			2			12 month storage limit if inhibited, 3 month if not inhibited
Butadiene	**R**	4			1			3 month storage limit
Chloroethane	T	4						
Diethyl Ether	**R**	4			2			12 month storage limit if inhibited, 3 month if not inhibited
Ethylamine	T	4						
Ethylmercaptan	T	4						
Hydrocyanic Acid	T	4				B		
Hydrogen	T	4						
Hydrogen Cyanide	T	4				A/B		
Isobutane	T	4						
Isopropylamine	T	4						
Methyl Mercaptan	T	4						
Methylamine	T	4						
Pentane	T	4						
Propylene Oxide	T	4						
Trimethylamine	T	4						
Vinyl Bromide	**R**	4						
Vinylidene Chloride	**R**	4			1			3 month storage limit
Diazomethane	T	Flam Gas		X				
Diborane [G]	T	Flam Gas				A		
Acetylene	T	Flammable Gas						

Table 2: Excerpt from HCOC Reactive Chemicals (Lab workers are prohibited from using these chemicals during significant events.)

CHEMICAL:	HCOC Reactive [R]/ Toxic [T]	NFPA Flammability Rating***	Oxidant [S/L/G]	Explosive	Peroxide Former Class**	Acute Toxicity: DOT Poison*	Waste Code***	Special Handling Requirements
Acetal	**R**				2			12 month storage limit if inhibited, 3 month if not inhibited
Acetaldehyde	**R**	4			2			12 month storage limit if inhibited, 3 month if not inhibited
Acetylenic Compound	**R**			**X**			P	
Acrylic Acid	**R**				1			3 month storage limit
Acrylonitrile	**R**	3			1			3 month storage limit
Acyl or Alkyl Nitrates	**R**			**X**				
Acyl or Alkyl Nitrites	**R**			**X**				
Alkyl Hydroperoxides	**R**			**X**			P	
Alkyl or Acyl Peroxides	**R**			**X**			P	
Butadiene	**R**	4			1			3 month storage limit
Chlorobutadiene [chloroprene]	**R**				1			3 month storage limit
Chlorotrifluoroethylene	**R**				1			3 month storage limit
Cumene	**R**	3			2			12 month storage limit if inhibited, 3 month if not inhibited
Cyclohexene	**R**	3			2			12 month storage limit if inhibited, 3 month if not inhibited
Cyclooctene	**R**				2			12 month storage limit if inhibited, 3 month if not inhibited
Cyclopentene	**R**				2			12 month storage limit if inhibited, 3 month if not inhibited

Boston College is in the process of choosing a chemical inventory management software package. This tool will allow us to manage a single, consistent, electronic inventory, and to flag HCOCs automatically.

Pollution Prevention and Chemical Redistribution (EPIs 3&4)

As stated in the previous Project XL reports, an on-going chemical redistribution program (EPI 4) is not cost effective. We continue to have lab clean-outs due to personnel changes or changing space needs, and these activities generate some unused chemicals. However, for the reasons mentioned in previous years (concerns for quality), only ~5% of the containers of unused chemicals may be taken by other labs. When we have a clean-out we make an effort to redistribute chemicals.

Other opportunities for Pollution Prevention continue to be elusive, especially in light of the current growth in research with a corresponding increase in waste production. In the ‘05-‘06 academic year we will be undertaking a new mercury elimination effort, with the primary goal of protecting our wastewater. We also expect that the electronic chemical inventory will be useful in managing purchasing, as people will see what is available in other labs. (As was shown in previous years, chemical borrowing from a known source is much more acceptable to researchers than taking an unused chemical from an unknown source.)

Hazardous Waste Generation (EPA #5)

Waste totals are presented in Table 3[2] and Figure 1. The 14% increase in waste from 2003 – 2004 has been noted anecdotally in our waste management operations in the past year. The Chemistry Department continues to grow, particularly in the area of organic synthesis. The incoming graduate class in September 2004 was roughly twice the size of previous incoming classes, and we have anecdotal reports that these students are interested in the organic synthesis labs. The impact of these students on waste production will not be seen until Spring/Summer '05 .

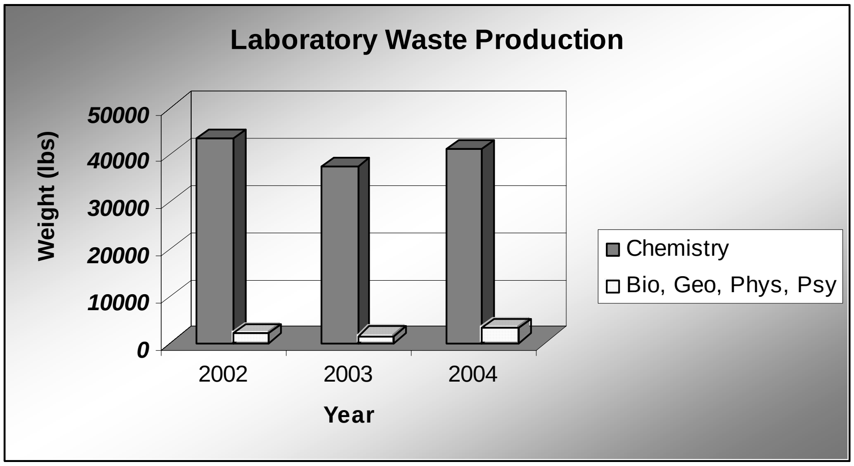
Another sign of expansion is redistribution of space in the Merkert Chemistry Center – the amount of laboratory space for the people in the organic synthesis group is growing, while space for some of the other laboratories is contracting. There is also discussion of adding one or more new researchers in this field, which is consistent with BC's commitment to expand the research science capacity by 25%[3]. I predict that waste volumes from the Chemistry Department will continue to increase due to department growth.

Table 3. Hazardous waste totals based on manifests (in lbs.)

		2002	2003	2004
Chemistry Department	Halogenated solvents	21,435	15,100	22,415
	Non-halogenated solvents	12,260	12,405	8,830
	Silica gel	2,575	750	2,380
	Lab Packs	7,102	9,274	6,930
Chemistry Total		43,372	37,529	41,297
All other labs	Lab Packs	2,094	1,515	3,101
Lab Waste Total		**45,466**	**39,044**	**44,398**
% inc/dec per year			-15%	14%
% inc/dec 02 - 04				-2%
Chemistry waste as % total		95%	96%	93%

[2] Waste totals determined from waste pick-up sheets are presented in Table 5 in the Appendix. The table provides more detailed information about the waste generating activities of individual departments. The discrepancy in totals between the pick-up sheets and manifests results from the additional weights of containers that are included in manifest totals.
[3] From 2003.

Figure 1. Change in waste totals over time.



There was also significant growth in the non-chemistry labs. The near doubling seen from 2003-2004 can be explained by addition of new faculty in Biology, Psychology and Physics, an increase in the number of graduate students, and an increase in the activity of the Physics Department. The Physics Department is gaining prominence in the field of nanotechnology, and while the results of their work are very small (and nanotechnology may eventually be a significant pollution prevention tool), the activity required to achieve those results has increased the amount of hazardous waste they produce.

The Campus Consortium on Environmental Excellence (c2e2.org) continues to be interested in understanding how it might be possible to normalize hazardous waste data in order to detect trends and understand the changes in waste production from year to year. Boston College and C2E2 are planning a symposium on normalization for the academic year ’05-‘06.

Environmental Awareness (EPI 6)

The Environmental Awareness Survey for 2005 was completed by 128 people in the Chemistry Department (Table 6). The survey was divided into four sections. Questions 1-8 were knowledge questions that have been asked in previous years. There were no significant differences seen in knowledge about lab procedures, except that undergraduates (understandably) have lower scores because they have had more limited training. These questions continue to point out where we need to provide better training. The addition of web-based training may be the difference that we need to get people to understand certain principles like how a fume hood works.

Questions 9-15 were questions about workers’ attitudes concerning their responsibilities in environmental issues and waste generation. It is pleasing to see that 76% of those surveyed agree or strongly agree that they do have responsibility to “minimize the environmental impact of their work (Q. 9).” However, only 48% agree that they *could* reduce their waste production by 10% (Q. 11). The responses to Question 13 suggest that researchers don’t have information on *how* to reduce waste production. Combined with the lack of readily accessible information about less toxic replacements in the scientists’ own literature, it suggests that there is a significant opportunity here for EPA to work with the American Chemical Society and other chemical manufacturing resources to encourage the development of new technologies that would allow for toxic use reduction.

Questions 16 and 17 were demographic questions.

Questions 18 -20 were new questions, and provided excellent program feedback for us in terms of improving our health and safety and waste management program. Question 18 is especially gratifying: of those who had grounds for comparison, 52% believe the BC program is better than other waste programs and a total of 93% believe that the BC program is better than or the same as other waste programs. The New England University Project XL has certainly had a positive impact on our lab waste management program at Boston College.

Specific information comes from the comments (Q. 19 and 20). We see that certain simple operational improvements, like better management of labels and waste bottles, training of safety contacts, and communication with our waste contractor, should positively impact the program with a very small amount of effort. It is also gratifying to know what our successes are. The data contained in the survey may provide additional insights upon further analysis, and I expect to continue to use customer surveys in the future to ensure the improvement of our program in the right direction.

Training (EPI 7)

There have been no significant changes in our training program over the last year. We continue to train nearly 100% of the lab workers, either with face-to-face initial training at the start of a semester, or with written training for interim arrivals who still have to complete face-to-face initial training at the next scheduled time. We also provide refresher training on request. The average Chemistry lab worker has a 3 hr. initial training and annual refresher training (1 hr.). The lab workers in other departments generally have 2 hours of initial training.

Training attendance is managed by departmental personnel, and is tracked by the departments and EH&S.

The Chemistry Department and EH&S are piloting a new training vehicle for the current academic year ('05-'06). WebCT is a web-based online learning software package supported at Boston College. Any classes that have online learning activities use WebCT, and there are an increasing number of students who are familiar with it. WebCT supports a number of formats and provides tracking for those who use it.

The first training program being introduced through WebCT in Chemistry is the emergency evacuation plan. This will be followed by DOT shipping training, chemical hygiene, and waste management. WebCT is not intended to replace face-to-face training, but will allow people to review materials at a slower pace, to have make-up training or initial training immediately on arrival at BC.

Objectives and Targets (EPI 8)

Objectives and targets are presented in the format of the Environmental Scorecard (Appendix III).

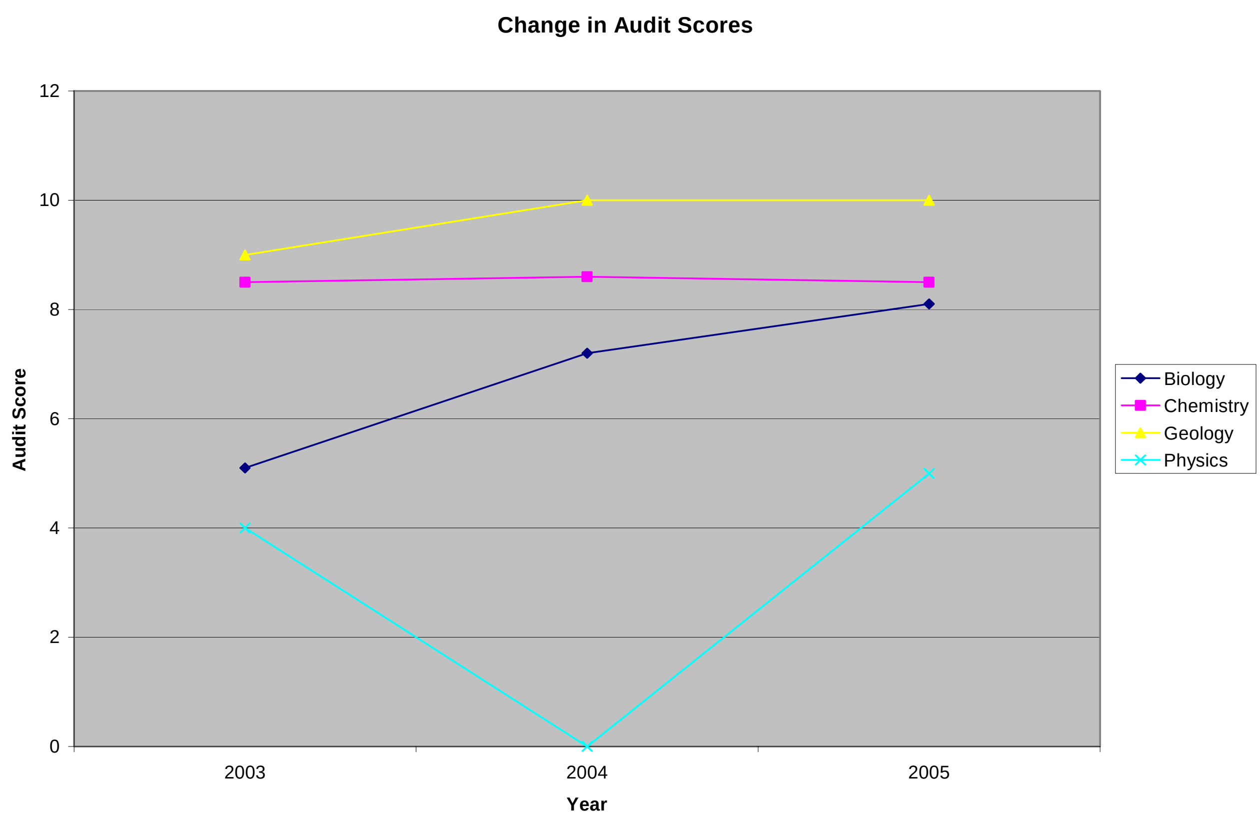
Audit Scores (EPI 9)

The trend in audit scores (Figure 2) suggests that our increased efforts in training and communication in the Biology Department are having a positive effect, as compliance is reaching the same level as the Chemistry Department. The two labs in Geology are under the control of one person, so compliance management in that department is very easy. Physics is the next frontier as far as targeting training to improve compliance. The Physics Department is undergoing a period of growth and change. It will be necessary in the current year to identify waste generation points and provide training targeted to Physics' activities.

Table 4: Average Audit Scores by Department from 2003-2005.

Report year /Department	2003	2004	2005
Biology	5.1	7.2	8.1
Chemistry	8.5	8.6	8.5
Geology/Geophysics	9	10	10
Physics	4	N/A	5

Figure 2. Change in Audit Scores



Conclusion

Boston College's participation in the Lab XL Project continues to provide us with opportunities to learn and inform about the challenges of waste management in laboratories at universities throughout the country and the world. Ultimately I believe this work will provide answers that support waste minimization and Green Chemistry, and will lead to a change in the culture of science such that we will take into account chemicals' health, safety and environmental impacts as well as their utility chemical dependent processes.

Appendix: Supporting Data

Table 5. Hazardous waste totals based on lab pick-up forms

Data collected from waste pick-up forms

	Weight (lbs.)					
Department	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Biology	1199	952	808	1287	data not available from waste pick-up forms	882
Chemistry	21598	35642	33363	33391		38742
Geology	23	24	85	(a)		55
Physics	N/A	46	25	46		82
Psychology	391	100	54	11		42
Total	23211	36764	34335	34735		39803

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

Table 6. Environmental Awareness Survey 2005

Question	Grad	Undergrad	Non-Stu	Totals	% Respondents
1. When I need health/safety information about a chemical I consult (check the two most common sources)					
a. paper MSDS	32	9	7	48	21
b. online MSDS	67	20	14	101	44
c. Merck	23	4	3	32	14
d. book	21	12	4	39	17
e. other	2	3	2	7	3
N				227	
2. Before I begin to work with a hazardous chemical I've never used before, I consult					
a. MSDS	39	8	13	61	31
b. chemical label	41	8	3	54	27
c. PI	5	5	4	14	7
d. colleague	40	15	4	60	30
e. other	6	0	1	7	4
f. no one	2	0	0	2	1
N				198	
3. Which of these factors do you think is the largest overall environmental impact of laboratory work:					
a. toxic chemicals	26	16	3	47	32
b. utility use	6	2	2	10	7
c. hazardous waste	61	9	15	87	58
d. biomedical waste	1	3	1	5	3
e. animal waste	0	0	0	0	0
N				149	
4. Which of these factors do you think is the largest overall environmental impact of YOUR laboratory work:					
a. toxic chemicals	28	7	4	40	27
b. utility use	6	6	3	16	11
c. hazardous waste	50	13	11	77	52
d. biomedical waste	9	4	1	14	10
e. animal waste	0	0	0	0	0
N				147	
5. A chemical fume hood works by					
a. air curtain	4	2	1	7	5
b. filtering chemicals	4	5	1	10	7
c. diluting chemicals	7	2	4	13	9
d. laminar flow	7	2	2	11	8
e. all	61	21	11	96	70
N				137	
6. What is the proper way to dispose of 1 liter of strong mineral acids?					
a. dilute	3	2	3	8	6
b. neutralization	37	14	4	57	42
c. collection and pick-up	46	12	11	70	52
d. mixing	0	0	0	0	0
N				135	

Question	Grad	Undergrad	Non-Stu	Totals	% Respondents
7. Ultimately, most chemical wastes generated in laboratories are:					
a. incinerated	50	6	10	66	50
b. landfill	1	1	1	3	2
c. sewer	3	0	0	3	2
d. treated	30	21	7	61	46
N				133	
8. In general, the cost of disposal of a chemical is ______ the cost of buying that chemical.					
a. less than	5	6	2	13	10
b. equal to	13	3	4	21	16
c. a little more	13	12	3	28	21
d. a lot more	51	7	9	69	53
N				131	
9. It is the responsibility of every lab worker to minimize the environmental impact of their work					
1. strongly agree	50	16	13	79	62
2	11	6	1	18	14
3	2	1	2	5	4
4	3	3	0	6	5
5. strongly disagree	16	1	1	19	15
N				127	
10. With careful planning, I would be able to produce 10% less laboratory waste without affecting my research output.					
1. strongly agree	14	7	5	26	22
2	18	10	3	31	26
3	25	7	4	36	31
4	13	0	2	15	13
5. strongly disagree	8	0	1	10	8
N				118	
11. Hazardous waste is a necessary byproduct of chemical research.					
1. strongly agree	15	2	3	20	17
2	31	14	10	45	38
3	13	11	4	28	24
4	12	0	0	12	10
5. strongly disagree	11	0	1	13	11
N				118	
12. It is important for scientists to find safer chemicals to use in their experiments.					
1. strongly agree	26	4	5	35	27
2	25	14	8	47	36
3	12	6	3	21	16
4	8	3	1	12	9
5. strongly disagree	11	1	1	14	11
N				129	

Question	Grad	Undergrad	Non-Stu	Totals	% Respondents
13. I would be willing to make changes in my experiments in order to produce less hazardous waste, but I don't know how.					
1. strongly agree	17	2	1	20	16
2	21	15	5	41	33
3	24	6	7	37	30
4	9	4	2	16	13
5. strongly disagree	10	0	1	11	9
N				125	
14. I have seen articles about pollution prevention in research in my discipline's journals.					
1. strongly agree	12	0	2	15	13
2	16	6	3	25	22
3	18	3	6	27	24
4	14	7	3	24	21
5. strongly disagree	13	4	4	21	19
N				112	
15. It is important to routinely review the health and safety information on the chemicals I use.					
1. strongly agree	29	4	5	38	30
2	25	15	6	46	36
3	11	5	4	20	16
4	10	4	3	18	14
5. strongly disagree	5	0	0	5	4
N				127	
16. Current Role					
Faculty				6	5
Staff / Admin				1	1
Staff / Lab Tech				11	9
Graduate Student				82	64
Undergraduate				28	22
N				128	
17. Years in research at BC					
<1				35	27
1-2				44	34
3-5				44	34
>5				6	5
				129	
18. I believe that the Laboratory Waste Management Program at BC is _________ the waste management programs at other universities.					
better than				42	32
the same as				33	25
worse than				6	7
I have no grounds for comparison.				45	34
No response				5	4
N				131	

19. The best/worst things about BC’s Lab Waste Management Program

The Best

every lab has specific person for safety issue
safety officers constant evaluation and checking in lab
review of incidents
training
informative

detailed training

the education

alert people all the time

they stress safety and caution

EH&S good staff
good waste bottles

well organized
staff are available for help and advice

reduces toxic chemicals in environment

prizes
frequent pickup of lab waste
fairly simple procedure for requesting pickup
scheduled pickup, those guys rock!

getting picked up frequently
scheduled pickup

rigorous attention paid by those in charge

informing how to get rid of chemicals
lab pickup of waste containers

emphasis placed on it
well organized
rigorous continued effort to pay attention to waste

collecting waste

nice guys, very efficient
yearly safety sessions
the multi colored tie wraps

The Worst

lack of training for that person

inconsistently enforced
waste bottles not kept in hoods
some waste I'm not sure what to do with
frequent lack of empty waste jugs
not enough info on what happens to waste, what goes in containers
Clean Harbors refuses to ask for entry to locked labs.
qualified people not in charge of the program
<u>not</u> separating chlorinated waste (it used to be separated)
pickup frequency. Sometimes too many waste bottles under fume hood
controlling waste water
should have easier access to the waste labels
methylene chloride in the drains
rigorous continued effort to pay attention to waste
could do with more communication (how to dispose of waste/separation)
occasional lack of empty waste bottles

the waste water nazi's
inconsistency
too stringent rules, no room for waste tubs
having to close the lid on waste jugs
saying that we would decrease overall emission w/o considering growth of dept.
sometimes waste bins aren't collected regularly
waiting for pickup
the fact that they commonly don't pick up materials they have sheets for
not enough room and bottles

its long
running out of empty waste bottles on Monday night
no separate collection of primarily solvent waste
no carbonyls(?) in lab
enforcement of vacuum aspiration

lab safety officers	none
the seminars	
weekly waste pickup	
how easy it is to get rid of waste	
waste company disposes of large bottles of reactives	
it is easy to get info helpful for proper disposal	
ease of use	
bottles and labels are readily available	
they actually have one and take it seriously	
its very informative	
It’s easy, safe, and fun for everyone!	
ease of waste pickup on weekly schedule	
waste tech entering labs	
close relation of safety people	
Easy access to waste management tools	

Table 7.
Audit results 2005

	Container mngment (a)	SOP (b)	Self Inspection (c)	Grade
	/4	/4	/2	/10
Biology				
	4	4	2	10.0
	4	4	0	8.0
	3	3	0	6.0
	4	4	2	10.0
	4	3	2	9.0
	4	3	0	7.0
	3	3	2	8.0
	4	3	2	9.0
	3	3	0	6.0
Average Score				8.1
Physics				
	3	2	0	5.0
Geology/Geophysics				
	4	4	2	10.0
	4	4	2	10.0
Average Score				10.0
Chemistry Research Labs				
	4	4	2	10.0
	4	3	2	9.0
	4	3	2	9.0
	4	4	2	10.0
	4	4	2	10.0
	3	3	1	7.0
	3	4	2	9.0
	3	3	0	6.0
	4	3	2	9.0
	3	4	2	9.0
	4	4	0	8.0
	4	4	2	10.0
	2	2	1	5.0
Chemistry Teaching Labs				
	4	4	2	10.0
	3	3	0	6.0
Average Score				8.5

(a) Containers closed, in good condition, segregated, in secondary containment
(b) Labels legible, no abbreviations, completely filled out
(c) Inspections done all the time