LAB XL PROGRESS REPORT FOR 2003

UNIVERSITY OF VERMONT

Submitted June 1, 2004

Summary

EPI Overview

After the initial three-year period of the implementation of the UVM Environmental Management Plan, it is clear that many of the goals for improvement in environmental performance as set forth in the Final Project Agreement have been achieved. Specifically, increased training of laboratory workers (EPI #7), facilitated primarily by the regulatory flexibility provided by the Environmental Management Standard, has led to a increase in awareness of environmental compliance issues by UVM laboratory workers (EPI #6).

This increased awareness has led to significant improvement in the compliance audit scores found by internal laboratory compliance audits (EPI #9) and the participation rate of laboratories in the Hazardous Chemicals of Concern inventory process (EPI #2).

The most important pollution prevention success of the EMP is found in the fact that participation in the UVM ChemSource program, the primary campus-wide hazardous waste minimization program, has nearly doubled over the course of the Project (EPI #4). An indicator of the value of the ChemSource program is provided by data that show only about 15% of UVM's laboratory waste stream consists of unused chemicals. The American Chemical Society estimates that, on a national basis, this number is close to 40%.

Other aspects of environmental performance identified as significant in the Final Project Agreement have had less clear results. Changes in the participation rate in the HCOC survey probably explains the increase in the number and amount of chemicals reported in the survey totals over the course of the project (EPI #1). Similarly, the amount of chemical waste produced by UVM laboratories has not shown any consistent trend since the project began (EPI #5), although in the context of a doubling of external research funding at UVM over the course of the project, the 20% increase in chemical waste generation in the same period can be considered a hazardous waste minimization success.

Two of the indicators named in the FPA are taking longer to develop useful information than expected. First, a program for identification of pollution prevention opportunities on campus as envisioned by EPI #3 is well underway, with more than 70% of UVM laboratories participating in the P2 survey and more than 50% reporting undertaking pollution prevention initiatives of their own volition. However, no clear opportunities for campus-wide programs to support development of specific P2 efforts have been identified. Because of the nature of chemical uses in the laboratory setting, we believe that it is unlikely that any single P2 technique will be identified beyond the chemical inventory management support provided by the ChemSource program.

The second indicator that has yet to be fully developed is EPI #8, which evaluates the Environmental Management Program effectiveness. The challenge presented by this EPI is that different indicators are of interest to various stakeholders in the program. For example, all parties agree that “continuous improvement” of environmental performance is supported by the “plan-do-check-act” basis of the EMP. However, with respect to hazardous waste minimization and disposal, laboratory workers are most involved in pollution prevention “planning”, while regulators are most involved in “checking”, and Environmental Safety staff are primarily involved in waste disposal and pollution prevention activities (the “do” and “act” portions of the cycle).

In order to provide indicators with meaning to this variety of stakeholders, we are reevaluating our approach to setting objectives and targets for the Environmental Management Program and are considering using the “balanced scorecard” approach to managing this program (see Appendix 3 for more information on this approach). The advantage of the balanced scorecard approach is that it allows a variety of indicators to be considered in developing specific program goals. The principle challenge to the balanced scorecard is managing the resource requirements that this variety of indicators requires in order to be implemented. Further exploration of this indicator is becoming more manageable as experience with the trends (or lack thereof) in the other eight EPI’s is gained.

Performance Orientation and Regulatory Flexibility

The national significance of this Project XL has increased since the 2003 progress report. This is because of sustained interest shown by federal regulators in the issues raised by application of RCRA regulations to laboratories. Many people look to the Lab XL project for information about what the likely results of extending regulatory flexibility, particularly in comparison to the traditional RCRA approach.

In particular two questions routinely arise: “What does ‘performance orientation’ mean?” and “Is regulatory flexibility really necessary?” While complete answers to these questions are probably not yet possible, the XL results to date do provide significant insights into these questions.

“Performance orientation” as implemented in the Lab XL Environmental Management Standard and Final Project Agreement means that the regulatory review of chemical waste handling practices focuses on the performance of the waste program as a whole rather than on specific procedures in the workplace. For example, the ability of the waste management program to identify and evaluate goals that are appropriate to hazardous waste minimization can be assessed. Such an evaluation would also review the effectiveness of mechanisms for capturing lessons that can be used to improve the program. In effect, a performance-orientation approach to regulation takes a step back from the details of waste management procedures to see how they connect to meet multiple goals. The challenge of the performance-oriented approach is that the beneficial effects of the larger view can take time to develop. In the case of the XL EMP, it has taken four years to develop an institutional program that can form the basis for a pro-active pollution prevention program while maintaining compliance substantially equivalent to RCRA requirements.

The environmental awareness and pollution prevention successes experienced in the XL project would not have been possible under the RCRA regulations. The emphasis that RCRA places on hazard determination and waste storage procedures requires that the waste management program focus limited human and financial resources on these procedures to the exclusion of pollution prevention considerations such as hazardous waste minimization. As noted in the discussion of EPI #7 below, 40% of the UVM lab worker population has two years or less of experience in a UVM laboratory. The regulatory training necessary to understand how RCRA applies to the diverse universe of research chemicals (a matter of ongoing disagreement among RCRA experts) requires a familiarity with both laboratory operations and RCRA requirements that would require most of those two years to acquire. The most important part of the regulatory flexibility afforded the schools in the Lab-XL project is the ability to adopt waste management procedures based on their specific circumstances and resources rather than on a RCRA model based on industrial processes.

EPI #1: Annual Surveys of Hazardous Chemicals of Concern

Table 1 gives the results of the 2004 Hazardous Chemicals of Concern survey at UVM. The survey demonstrated stable results with respect to the number and amount of chemicals being stored in UVM laboratories compared to 2003.

Table 1: HCOC Inventory Trends at UVM
2001 - 2004

	2001 XL baseline year	2002	2003	2004
Forms distributed	453	220	217	222
Labs reporting (counted by room in 2001, by lab supervisor in other years)	220	160	202	187
Supervisor response rate	49%	73%	93%	84%
Chemical count per lab	16	19	24	23
Total pounds of HCOC per lab	134	153	190	185

EPI #2: Verification of HCOC Surveys

EPI #2 measures the number of laboratories that return HCOC surveys in time to be included in the SARA Title III report to the Vermont Department of Emergency Management. This number dropped in 2004, but is still greater than before the XL project began.

A significant problem with achieving complete compliance with the HCOC survey is the fact that a significant portion of laboratory supervisors and workers change each year as research projects end and new ones begin. Previous reports have highlighted the procedural difficulties presented by this factor. The process of conducting the HCOC survey requires careful oversight of more than 200 laboratory groups based on information from field visits and departments. This oversight is resource intensive and competes with other program efforts such as training and laboratory audits.

We do not believe that less than 100% participation negates the validity of the HCOC survey process. The first purpose of the survey, preparation of the SARA Title III report, effectively highlights the buildings that contain the largest amount of laboratory chemicals at an appropriate level of detail for emergency response purposes. For Project XL purposes, the HCOC survey provides a statistically effective measure of the amount of chemicals stored in UVM laboratories and changes in this amount over time. We believe that this result is important in supporting the performance goal of assuring that unusual chemical hazards in the laboratories are identified and properly managed. In addition to the HCOC survey, the laboratory audit program described in the discussion of EPI #9 supports this performance goal.

EPI #3: Pollution Prevention Opportunity Assessments

Aside from the Chemsource program (see EPI #4), the primary pollution prevention activity within the Environmental Management Program is an ongoing review of hazardous waste generation activities to identify opportunities for process changes that produce less chemical waste. Over the course of the XL project, this review has been implemented through a Pollution Prevention survey that has been included in the laboratory compliance audit process. The results of this survey, which has taken two years to conduct, are provided in Appendix 1. At this point, more than 70% of campus laboratory supervisors have participated in the survey.

The survey has two parts. The first seeks to gather supervisor's views on pollution prevention activities and opportunities in their laboratory. The second reviews their chemical inventory management practices to identify opportunities for increasing recycling of laboratory chemicals within the institution.

With respect to the first part, 58% of the laboratory supervisors report having taken advantage of one of the three primary forms of pollution prevention (downsizing of chemical reactions, substitution of less hazardous chemicals, or changing laboratory processes). This has not been motivated by regulatory obligations, but rather by the fact that the primary impact of the hazards of laboratory chemicals is felt by the people using the chemicals and therefore, they are highly motivated to find less hazardous approaches to their work.

The second important finding from the survey was that laboratories do not perceive a significant problem in terms of chemical supply management. Eighty-six percent of the laboratories report running out of chemicals annually or less. This finding indicates that the market for recycled laboratory chemicals is limited and is probably adequately met by borrowing chemicals from their neighbors.

EPI #4: Hazardous Materials Reuse and Redistribution

Campus participation in the ChemSource program was at the same level in 2003 as in 2002. This is about twice as much as at the beginning of the XL project. We believe that this leveling off indicates that laboratories are using the program at the appropriate level, given their routine chemical needs. We attribute this increase to improved awareness of the program on campus because of promotion as part of the laboratory audit process and ongoing interest in laboratory hazard reduction. Participation in the ChemSource program was specifically included as a pollution prevention audit point in the 2003 laboratory compliance audits.

The long-term value of the ChemSource program was demonstrated in 2003 by monitoring the laboratory waste streams for unused chemicals. The American Chemical Society's report "Less is Better" suggests that about 40% of most laboratory waste streams are unused chemicals. UVM's laboratory chemical waste consisted of 15% unused chemicals in 2003.

The most important reason for this EPI was to determine whether the regulatory flexibility provided by the development of an Environmental Management Plan would increase the amount of hazardous chemicals recycled from campus laboratories via the waste management office. Although the goal of a 20% increase in the number of recycled chemicals has been met, this avenue is limited as a pollution prevention opportunity. We believe that this limitation is because the potential market for laboratory reuse of surplus chemicals is small (see EPI #3).

Table 2: UVM ChemSource Deliveries

	2000 (XL baseline year)	2001	2002	2003
Total deliveries	440	503	854	863
Recycled chemicals	11	6	35	25

EPI #5: Laboratory Waste Generation Rates

Table 3 gives the amounts of chemical wastes generated by UVM laboratories over the course of the XL project. Note that this includes all chemical wastes and is not limited to RCRA wastes. For example, ethidium bromide is routinely used in many biologically-oriented laboratories (it is used to dye DNA molecules for genetic analysis) and is not a RCRA hazardous waste. Between 2001 and 2003, ethidium bromide rose from 1.4% of UVM's laboratory waste stream (2188 pounds) to 5.1% (3668 pounds) and is likely to continue increasing.

This example demonstrates the difficulty of interpreting chemical waste generation data within the context of constantly-changing research environment. Not only do chemical processes changes routinely, but the rate of change will vary depending on the type of research being conducted, the irregular cycle of funding and conduct of research projects, and technical changes in the way science is performed.

Given the many variables involved in determining the quantity of laboratory chemical waste being produced, it is unlikely that we will develop a viable approach to statistically explaining the effects of the EMP on the amount of waste generated by UVM laboratories. Interviews with managers of UVM's research program have consistently indicated that scientific laboratory research dominates the institutional funding picture. Therefore, it is anecdotally interesting to note the most easily available measure of research activity at UVM, research funding, has doubled over the life of the project while chemical waste generation has gone up by one-fifth. This contrast in these trends provides encouragement that the regulatory flexibility that forms the basis for the UVM EMP is achieving the goal of promoting hazardous waste minimization without necessarily achieving the specific goal of EPI #5.

Table 3: UVM Laboratory Waste Generation Trends

	2000 (XL baseline year)	**2001**	**2002**	**2003***
Lab Waste (pounds)	38,269	33,387	53,112	46,246
Change from previous year		-13%	59%	-13%
Cumulative change since 2000			39%	21%

EPI #6: Environmental Awareness Survey

The environmental awareness survey scores maintained their project-long trend of ongoing small improvement in 2004. In order to gain more information about the effectiveness of the environmental safety training program, the environmental awareness survey was divided into two this year: an environmental awareness survey, developed in concert with the other two XL schools and a safety awareness survey, which included questions outside the Environmental Management Plan. Between the two surveys, half of the questions on the old survey were asked; therefore an overall score similar to those calculated during previous years could be assessed. This score showed a 7% increase in 2004 over that of 2003.

We believe that this indicates that the training program is continuing to show success, with a high lab worker participation rate (fuelled primarily by word of mouth from other lab workers) the key component of this success.

Table 4: Environmental Awareness Survey Trends at UVM

Question	**2000 (pre-XL)**	**2001 (XL baseline)**	**2002**	**2003**	**2004***
Total Score *(% change from previous year)*	656	857 *+31%*	865 *+1%*	909 *+5%*	974 *+7%*
Years in UVM labs (% 2 years or less)	28	47	41	45	40
Role (% lab techs)	56	42	59	58	44
EMP Training (% attended)	0	86	96	87	94

* Note: 2004 score based on corresponding questions spread across two surveys

EPI #7: Environmental Awareness Training

The number of UVM workers that attended environmental awareness training in 2003 was up 6% over 2002. This continued growth is based on ongoing outreach through laboratory audits and the laboratory road shows. We will continue to develop innovative approaches to providing appropriate information to the laboratory audience so that awareness of regulatory compliance and pollution prevention issues does not fade.

An important demographic finding that came out of the awareness surveys was that about 40% of the laboratory worker population has been working in UVM laboratories for two years or less. Because of this turnover, the emphasis of the training program is on promoting lab worker awareness of the environmental safety issues associated with their work and explaining how they find can assistance with these issues, either within their lab or the University level. Training that focuses on a procedure-based disposal program closely tied to a government regulation such as RCRA creates a significant learning barrier by requiring acquisition of a non-intuitive vocabulary and a set of practices disconnected from standard laboratory procedures. The advantage of the Environmental Management Plan approach to chemical waste management is that it enables trainers to connect waste management procedures seamlessly to other laboratory safety practices.

Table 5: Environmental Training for UVM Workers

	2000	2001 (XL baseline year)	2002	2003
Total number of people trained	284	600	607	641
Demographic break down of lab workers attending training (data available for 2001 - 2003)				
Faculty		20%	10%	10%
Lab Staff		38%	38%	58%
Non Lab Staff		14%	20%	8%
Students		28%	32%	25%

EPI #8: Environmental Management Program Effectiveness

As mentioned in the summary, EPI #8 has proven the most problematic in terms of development of clear results. This EPI recognizes that the goals of a management program will change with time as the program improves by allowing the goals to be set and modified by each institution.

However, setting goals for this EPI at UVM has proven problematic due to the changing context of the indicators as the program has evolved with time. This challenge is to be expected in an EMS based system with a “Plan, Do, Check, Act” orientation, as the management program will focus on different parts of the cycle over time depending on the progress of implementation. Thus the indicators of interest will change over time as well.

For example, in the first year of the XL project, the training and awareness EPI’s (which indicate planning activity from the lab worker’s point of view), were key to the early development of the program and this is where most of the success was demonstrated. As the program proceeded, behavioral indicators (measuring the “Do” portion of the EMS cycle) such as the participation in Chemsource inventory management program and HCOC participation rate became more important, because they indicated the degree to which laboratory workers acted on the information provided during the training.

In 2004, “do” indicators began leveling off, but indicators that measure “check” activities (such as the compliance audit scores) continue to improve; this trend is expected to continue as improvement in laboratory oversight continues. The “act” step of the EMP process involves acting on the information developed during the earlier to stages to generate process improvements. In the case of the UVM EMP, involvement in pollution prevention activities as measured by EPI #3 represents this fourth stage of the EMS cycle. In this case, information from this “act” indicator has yet to be fully developed but information from the other indicators will be crucial for developing this portion of the program. Another example of “act” cycle activities is making changes in appropriate EMP procedures (such as the laboratory audit form) to improve the process.

It should be noted that this four-pronged approach to evaluating the effectiveness of the EMP parallels the Balanced Scorecard approach to organizational goal setting and indicators. Appendix 3 includes an essay published in the Vermont Environmental Monitor that discusses why this approach may be especially apropos for environmental indicators. This type of indicators has been traditionally problematic to use for finding ways to improve environmental performance.

Within the context of the overall set of indicators, the remaining two indicators, the amount of HCOC on laboratory shelves and amount of laboratory waste become more valuable. This is because they represent the two major regulatory concerns associated with the physical aspects of laboratory chemical waste: accumulation of hazardous chemicals in laboratories and the amount of hazardous waste generated from laboratories. While indicators have not developed any clear trends, the other indicators demonstrate that this is more likely to be an effect of the nature of the research process rather than lack of management commitment to those goals.

An important point to remember is that the development of this more complete picture of the EMS-based program requires regulatory flexibility in order to be successfully implemented. Because of the evolving nature of the program's focus of activities and indicators of success, reliance on a single "key" indicator to determine compliance will defeat the ongoing improvement of the program. While compliance with the minimum performance criteria is clearly necessary, methods of managing this compliance will evolve as the institutional program moves forward in the continuous improvement cycle.

EPI #9: Environmental Management Plan Conformance

EPI #9 measures the level of conformance to the Minimum Performance Criteria by laboratories at UVM. Table 6 gives the trends in this measure over the course of the project. Laboratory audits conducted in 2003 showed continued significant improvement, with a 53% increase in the average score over 2002 and a "model laboratory" rate six times that of 2002. "Model laboratories" are those that score 80% or better on both environmental compliance and laboratory safety criteria.

The basis for this success is the ongoing improved communication and partnership between UVM laboratories and Environmental Safety personnel. This communication improvement is enabled by the regulatory flexibility of the Environmental Management Standard because this flexibility permits much clearer, UVM specific procedures to be developed. Concerns about how UVM procedures are affected by RCRA interpretations are taken out of the laboratory setting and managed by personnel with extensive RCRA training and experience.

In 2003, Environmental Safety staff completed audits in the College of Medicine and Department of Chemistry. This represents slightly more than half of UVM laboratories. The remaining laboratories will be audited in 2004, and a "mini-audit" program is under development to provide institutional oversight for labs that do not undergo a full audit every year.

Table 6: Trends in UVM Environmental Compliance Audit Scores

	2001 (XL baseline year)	2002	2003*	% change in scores (2002-03)

Average total score (11 points possible)	2.9 points	5.1 points (7% "model labs")	7.8 points (43% model labs)	53%
*2003 audits covered only the Department of Chemistry and College of Medicine laboratories				

Appendix 1: UVM Laboratory Pollution Prevention Surveys

Table 7: P2 Survey Results 2002-2003
number of responses = 184 (71% of lab supervisors)

Part 1: Chemical Process Management

		Number of labs	% of labs
Type of Wastes Generated *(multiple answers possible)*	Toxics	136	74%
	Solvents	114	62%
	Acids	96	52%
	Corrosives	80	43%
	Reactives	35	19%
Dominant Laboratory Processes *(multiple answers possible)*	Biomedical	72	50%
	Analysis	48	33%
	Synthesis	25	17%
	Other	14	10%
P2 Steps Taken *(multiple answers possible; 58% of labs report using at least of these three steps)*	Downsizing chemical reactions	79	43%
	Substitution of less hazardous chemicals	87	47%
	Changing laboratory processes	64	35%
Frequency of process changes	Never	44	24%
	Annually	76	41%
	Monthly	36	20%
	Weekly	25	14%
	Daily	10	5%
Waste generation trends	Decrease	37	18%
	Stay the same	154	74%

	Increase	18	9%

Part 2: Inventory Management Practices			
How often do you run out of a chemical?	Once a month	26	14%
	Once a year	94	50%
	Never	67	36%
Alternative sources of a chemical *(multiple answers possible)*	Borrow from another lab	92	63%
	Would check UVM chemical exchange program for the chemicals they need	76	52%
	Standard shipping from vendor	53	37%
	Overnight shipping from vendor	37	20%
	Substitute with another chemical	20	14%
How frequently do you borrow chemicals from another lab?	Never	31	21%
	Annually	60	41%
	Monthly	42	29%
	Weekly	7	5%
	Daily	1	1%

Appendix 2: Laboratory Worker Awareness Surveys, Spring 2004

Table 8: UVM Lab Worker Environmental Awareness Survey Spring 2004 (50 responses)

Question	Response chosen (%)				
1. When I need health/safety information about a chemical I consult (indicate the two most common sources):	*MSDS* 88	*Merck Manual* 8	*Laboratory Chemical Safety Summary* 22	*Supervisor* 25	*A Lab Colleague* 26
	Use of toxic chemicals	*Utility use (energy and water)*	*Hazardous waste production*	*Biomedical/sharps waste production*	*Animal waste production*
2. Which of these factors do you think is the largest overall environmental impact of laboratory work:	20	28	46	6	
3. Which of these factors do you think is the largest overall environmental impact of laboratory work:		46	52	26	6
4. The purpose of a fume hood is to protect (pick the best answer as it applies to your work):	*The laboratory worker* 68	*Equipment in the laboratory* 0	*The laboratory building and its occupants* 32	*The outside environment* 0	

	1 **Strongly agree**	**2**	**3**	**4**	**5** **Strongly disagree**
5. It is the responsibility of every lab worker to minimize the environmental impact of their work.	80	6	0	6	8
6. With careful planning, I would be able to produce 10% less laboratory waste without affecting my research.	18	24	36	14	8
7. Hazardous waste is a necessary byproduct of chemical research.	18	38	32	6	4
8. It is important for scientists to find safer chemicals to use in their experiments.	46	20	14	12	8
9. It is not my responsibility to make changes in the way my research is done in order to produce less hazardous waste.	8	6	8	20	58
10. I have seen articles about pollution prevention in research in my discipline's journals.	16	8	18	26	32
11. What is the proper way to dispose of strong mineral acids?	*Dilution with water* 8	*Neutralization with lime* 6	*Collection for pick-up by hazardous waste personnel*	*Mixing with organic chemicals* 2	

			84		
12. Ultimately, most chemical wastes generated in laboratories are:	*Incinerated* 16	*Sent to a landfill* 8	*Released to a sewer* 14	*Treated* 60	

13. In general, the cost of disposal of a chemical is _______ the cost of buying that chemical.	*Less than* 12	*Equal to* 12	*A little more (less than twice as much)* 26	*A lot more (more than twice as much)* 48	
14. In general, how are fume hood emissions treated before being released to the environment?	*Filtration to remove particles* 24	*Carbon filtration to remove gases* 24	*Dilution with laboratory room air* 28	*Scrubbing to remove particulates, gases and toxics* 24	
15. Please check the types of laboratory worker training you have received at UVM.	*Chemical Safety* 45	*Radiation Safety* 28	*Biosafety* 24	*Laser safety* 1	
16. What is your current role in your laboratory?	*Faculty* 4	*Staff* 46	*Grad student* 46	*Undergrad student* 4	
17. How long have you been working in a university lab?	*less than 1 year* 8	*1-2 years* 30	*3-5 years* 36	*more than 5 years* 26	
18. Have you completed an XL Environmental Awareness Survey in the past?	*Yes* 24	*No* 72			

Table 9: UVM Lab Worker Safety Awareness Survey Spring 2004 (100 responses)				
Question	**Response Chosen (%)**			
1. How can you know what classes of hazards are associated with the chemicals in your lab?	*Look on the chemical container label* 3	*Look at the Material Safety Data Sheet* 3	*Consult the Chemical Use Planning Forms in your lab* 2	*All of the above* 92
2. What are the 2 work practices that most reduce your chances of infection with a bloodborne pathogen in the work place?	*Standard Precautions and handwashing* 13	*Standard Precautions and training* 3	*Standard Precautions and Hepatitis B vaccine* 1	*Wearing gloves and Hepatitis B vaccine* 12
3. What are the three pieces of information that must be on all chemical labels?	*0 responses* 3	*1 responses* 10	*2 responses* 33	*3 responses* 54
4. When a container that held an acutely toxic chemical, pesticide, heavy metal, mutagen, teratogen or carcinogen is empty how do you dispose of it?	*Put the cap back on securely and tag the container as chemical waste for pickup and disposal by ESF staff* 97	*Rinse them out and recycle them* 1	*Throw them in the trash* 2	*Autoclave them and put them in a biowaste dumpster.*
5. If your supervisor designates you as "at risk" for exposure to bloodborne pathogens in your work how often must you have Bloodborne Pathogens Safety Training?	*Before you are exposed to any potentially infectious material and then every 12 months* 24	*Before you are exposed to any potentially infectious material* 3	*Before you are exposed to any potentially infectious material and then every 3 years* 1	
6. MeOH is an acceptable abbreviation for methanol on a container in your lab.	*True* 9	*False* 91		
7. What is the proper	*A piece of masking*	*A yellow Laboratory*	*A Laboratory Waste*	

way to label containers of chemical waste in the lab while the waste is being accumulated?	*tape is adequate* 0	*Waste Accumulation Container sticker* 93	*Tag* 5	
8. How does the Environmental Safety Facility (ESF) staff know that you have chemical waste to be picked up from your laboratory?	*They check every lab on campus once per week.* 5	*They receive a copy of the lab waste tag in the campus mail (or on line) from the lab workers* 91	*ESF staff are psychic and just know when there is waste to be picked up.* 0	*They receive notification after laboratory compliance audits are completed.* 4
9. Why are you not allowed to store flammable liquids in household refrigerators and freezers or cold rooms?	*Corrosion of the cooling elements* 2	*Storage of flammables in household refrigerators and freezers and cold rooms IS allowed.* 1	*Flammable vapors can accumulate in unventilated areas, leading to explosive situations* 96	*EPA regulations prohibit the practice* 1
10. Your eyewash and safety shower need to be flushed every __________ to avoid microbial growth.	*Month* 0	*Year* 6	*Day* 2	*Week* 91
11. How often do you need to change your gloves when working with chemicals?	*At the end of the day* 0	*Whenever they get contaminated with a chemical* 92	*Depends on what kind of glove they are* 7	*You don't; washing them with water at the end of the day is adequate* 1
12. A chemical cannot have more than one hazard associated with it.	*True* 5	*False* 95		
13. Name the 4 "routes of entry" through which hazardous chemicals can enter your body.	*1 responses* 4	*2 responses* 3	*3 responses* 67	*4 responses* 25
14. After you have the three shots of the Hepatitis B vaccine series what should you have checked?	*Your Hepatitis titer, to see if you are immune to Hepatitis B.* 29	*Your Hepatitis titer, to see if you are immune to all forms of Hepatitis.*	*Your Hepatitis titer, to see if you are immune to Hepatitis B and Hepatitis A.* 1	*Your Hepatitis titer, to see if Risk Management will pay for the series.*
15. The LD50 value is a measure of the	*Flammability*	*Corrosivity*	*Reactivity*	*Toxicity*

of a chemical.	4	1	1	91
16. What is your current role in your laboratory?	*Faculty* 10	*Staff* 42	*Grad Student* 41	*Undergrad Student* 7
17. How many years have you been working in college or university laboratories?	*< 1 year* 5	*1-2 years* 37	*3-5 years* 22	*> 5 years* 35
18. Have you attended UVM's Chemical Safety and Environmental Awareness Training?	*Yes* 96	*No* 4		

Appendix 3:
Article "Placing Environmental Indicators in Context"

Written by Ralph Stuart, Environmental Safety Manager, University of Vermont
published in the Vermont Environmental Monitor

The development of an Environmental Management System (EMS), as described in the ISO 14000 standards, is a multi-step process. The steps include identifying an organization's environmental aspects and impacts, reviewing regulatory requirements for applicability, setting environmental goals and objectives, and then prioritizing these issues by their "significance."

In many organizations, the analysis process can be lengthy and complicated, however, the goal is a simple one: identifying key indicators that can be used to track the success of the EMS at preventing pollution. The success, or lack thereof, is used as a guide to the ongoing development and improvement of the EMS. Which "key indicators" are chosen will vary from organization to organization, but examples could include the amount of energy used during the manufacture of a product; the amount of hazardous waste disposed of by a particular facility; or the ability of the organization's products to be recycled after they have been marketed.

One of the major criticisms of the ISO 14000 standard is that it provides little guidance for ranking the significance of the various environmental indicators, beyond the general assumption that regulatory compliance is "required" and therefore any regulatory indicators are of high significance. In most organizations, the people developing an EMS will identify many potential environmental indicators and careful thought about how to select and prioritize these indicators is needed so that the EMS will meet the needs of the many different stakeholders interested in its success.

Since the Environmental Management System approach is based on the ideas of more general management concepts such as continuous improvement and Total Quality Management, it makes sense to look to current management theory to see how prioritization of indicators is managed there. A new approach to managing indicators emerged in the 1990's called "the Balanced Scorecard." This column will discuss how the Balanced Scorecard approach might be used in organizing indicators within an environmental management system.

Traditional Methods

Environmental indicators are specific measurements identified as strategically important to the success of the environmental program. There is a strong preference in selecting numerical indicators, which can measure more subtle changes in performance than qualitative indicators. However, a numerical indicator is only meaningful when we understand the significance of the measurement in context. For example, the question "Is 5 tons per year of hazardous waste good performance or poor?" can only be answered if there is some context for the number.

In a closely related example, industrial hygienists might try to identify the significance of a specific amount of gas vapor in a worker's breathing zone. A finding of five parts per million of chemical X means nothing unless there is a standard to compare the reading to. In the case of airborne concentrations, industrial hygienists often use external standards, such as the OSHA Permissible Exposure Limit. However, the controversial nature of this standard can be gauged by the number of competing standards established for the same chemicals. For example, the American Conference of Governmental Industrial Hygienist's Threshold Limit Values, NIOSH's Recommended Exposure Levels, and the American Industrial Hygiene Association's Workplace Environmental Exposure Levels are alternative choices for standards to compare a breathing zone measurement to. Which of these external standards is chosen will be based on the professional judgment of the industrial hygienist(s) and the specific goals of the sampling situation.

Because using external standards can be problematic, many environmental managers turn to other approaches for working with indicators. There are three traditional approaches to placing numbers in context: normalization, trending and benchmarking. While these can all be applied to environmental indicators, they each have significant limits for this use.

Normalization

Normalization is the most common approach to assessing indicators and is done by identifying a second number that can be used to establish a ratio to an indicator. The most common way to normalize an indicator is to establish a "per manufactured unit" or "per person" basis for comparing the indicator before and after a change in the process.

Normalization works best when the ratio is established between indicators related by a cause and effect chain. That is, there is a clear, direct link between a change in the normalization factor and a subsequent change in the indicator. The problem for many environmental indicators is establishing that link with data on activities (number of employees, production rate, etc.). Because environmental impacts are side effects of an organization's activities, there is seldom a direct link between the indicator and any factor the organization is measuring as part of its production process.

For example, the amount of hazardous waste produced by a facility will be influenced by many variables, including: the amount of hazardous waste associated with the "baseline" operation of the facility; the incremental increase in hazardous waste generated by making additional products; changes in the process used in the manufacturing process; and changes in the regulations determining what is hazardous waste. In order to develop a reliable normalization formula for the amount of hazardous waste, one would have to determine the relative numerical importance of all these factors and adjust the factors as this relative importance changes with time.

Similarly complicated stories can be told for almost all environmental indicators because facilities and processes are not designed and built around these "side effects" of their operation, but rather with the focus on the efficient production of the goods and services of the organization.

Trends

A second approach to putting indicators in context is to compare the same number over time. This is often the simplest approach because it avoids the problem of developing a complete explanation for how environmental impacts are caused. A common example is a state's requirement for the development of pollution prevention plans that reduce the amount of hazardous waste produced each year. Unfortunately, this "simple" approach also limits the usefulness of trend data because it does not identify specific factors that drive the indicators and so it is often unclear how these trends can be changed in the future.

Benchmarking

A third traditional approach to putting indicators in context is to compare indicators to the same numbers from other organizations. For example, a competitor producing the same product may produce a smaller amount of hazardous waste, indicating that they have a better process. The challenge here is to identify situations that are similar enough that the measurement of a specific indicator has the same meaning for both organizations. As the industrial hygiene example above shows, establishing meaning can be difficult with reasonably simple indicators. Environmental indicators with multiple causes present even larger problems in evaluating the similarities and differences between organizations.

It should be remembered that these different approaches can be, and commonly are, combined. For example, annual trends in normalized indicators can be used to determine the success of an environmental program.

The Balanced Scorecard Approach

Because of the many challenges I've described above, many environmental professionals are interested in going beyond the ISO 14,000 approach to indicators. One promising approach comes from more general management thinking. Business management theorists have recognized the hazards of working with a small set of simple indicators, such as stock price, salary or profits in managing an organization. In fact, some of the most notable business failures have resulted from an over reliance on a single indicator for assessing a business's health (for example, stock price for many of the "dot com" companies). The challenge increases when multiple indicators are included, as comprehensive Environmental Management Systems envision.

In order to use indicators in a more effective way, a new approach to strategic management was developed in the early 1990's by Drs. Robert Kaplan and David Norton. Their approach is called the "balanced scorecard." The "scorecard" aspect of their approach is establishing a group of indicators of roughly equal priority and setting goals for those indicators, rather than relying only on specific key indicators. At its simplest, a Balanced Scorecard typically consists of a collection of between 15 and 40 performance measures, clustered into 4 groups with target values for each of these measures. The "balanced" aspect involves sorting the selected indicators into groups depending on what they mean.

At its most general level, the balanced scorecard approach suggests that a management system view the organization and the indicators established for it from four perspectives: Learning and Growth, Business Process, Customer, and Financial. Others have described these perspectives in more concrete terms as being related to different stakeholder groups (respectively): employee indicators, business efficiency indicators, customer indicators and shareholder indicators.

The strength of the balanced scorecard approach is that it allows the indicators to be explicitly organized in a way that provides "checks and balances" between the organization's different constituencies. A complete scorecard will include descriptions of why each measure was chosen and the projects or initiatives underway to move the indicator in the target direction.

The Balanced Scorecard Approach and Environmental Indicators

Can this management approach be used within an Environmental Management System? While the groups interested in the indicators of an EMS are probably different than those identified above, a similar map of the environmental stakeholders can be developed. (The ISO EMS development process specifically includes identification of stakeholders as an important step.) For example, it is relatively simple to identify four primary stakeholders interested in the environmental aspects of a facility: management, employees, the government and the surrounding community.

Each of these groups is likely to focus on different aspects of environmental performance. Management is interested in satisfying environmental requirements without hindering financial or operational performance; employees are primarily concerned about environmental conditions inside the facility; the government is interested in assuring that its regulations are observed; and the surrounding community is often interested in "beyond compliance" issues - situations that affect the immediate neighborhood without violating any regulations.

For example, in a fully developed EMS, management may choose to use environmental indicators that provide insight as to the cost of environmental protection; employees may be concerned with airborne chemicals in the workplace; the government may be primarily concerned with air pollutants which contribute to acid rain several states downwind of the facility; and the surrounding community may be concerned about noise levels near the facility's boundary. In the balanced scorecard approach, no one of these factors dominates the environmental program. Rather, the environmental manager sets goals for each factor, and explains program priorities in terms of how each factor affects the others.

The process of first identifying the stakeholders, and then the indicators of interest for those stakeholders, is a significant undertaking. Too long a list for either and confusion is likely to reign. 10 to 12 indicators sorted into four groups seems a reasonable goal in most balanced scorecard applications.

At UVM, we have had some experience with an approach similar to the balanced scorecard. Development of the Tracking UVM report (http://www.uvm.edu/greening/trackinguvm.html) involved an extensive stakeholder process that included UVM's upper management, campus staff involved in environmental programs, the campus community at large, and the local community.

The report organized the resulting set of 12 indicators of interest into 3 groups by related environmental aspects (land and water use; energy use and air pollution; solid and hazardous waste). In addition, qualitative indicators for "Academics and Culture" were provided to reflect the organization's primary mission of education, research and service and its relation to UVM's environmental impact. In this specific situation, these groupings met the needs of various stakeholders while maintaining a coherent framework for the indicators. The step of identifying targets to complete the "scorecard" part of the report was omitted due to resource and time constraints. This work on setting institutional goals to complete the scorecard is continuing.

In the case of Tracking UVM, the quantitative indicators are given additional context by including data trends for the indicators over the decade of the 1990's. This combination of trend data with stakeholder input demonstrates the potential value of combining traditional uses of indicators with the larger context provided by the Balanced Scorecard approach.

Conclusion

The environmental performance of an organization is a complicated thing to assess because 1) there are many different aspects to the performance and 2) it is difficult to find the information needed to place environmental measurements in an appropriate context. This difficulty often results in simplistic approaches to assessing the value of an environmental performance (how much does it cost? are all government regulations being met?) that relies on one or two indicators of success. Full development of an Environmental Management System is likely to produce a long list of indicators that must be carefully organized in order to provide useful information. The Balanced Scorecard approach, developed around financial management issues, is a promising paradigm that can help an organization resolve many of the complications of environmental indicators and develop clear priorities for an environmental program.