Chemical Strategies Partnership

Exploring Whether Chemical Management Services are a Potential Mechanism to Facilitate the Reduction, Reuse and Recycling of Chemicals in Educational Institutions

Final Report

(Revised January 8, 2004)

EXECUTIVE SUMMARY

Secondary schools, colleges, universities, and laboratory research facilities use chemicals as part of their educational and research programs. Recent EPA regional enforcement initiatives focusing on colleges and universities, and chemical incidents in secondary schools and research facilities show the need for improvement in their management of chemicals. In response, educational institutions are struggling to find effective approaches to better manage chemicals.

With the funding from the U.S. EPA Office of Solid Waste, this research project aimed to evaluate the viability of the Chemical Management Services (CMS) model for facilitating reduction, reuse and recycling of chemicals in colleges and universities. A project with colleges and universities has greater transferability potential to the broader educational and research arenas. The specific objectives of this project are to:

- Develop at least two case studies on chemical management approaches used by colleges and universities.
- Recruit an institution to participate in a pilot exploring the use of CMS.
- Lay the groundwork for the pilot to explore whether a CMS program could more cost effectively facilitate chemical management, including the reduction and elimination of mercury, in a college or university. The actual pilot will occur as a second phase to this project.

Review of current chemical management practices suggests the following major challenges for colleges and universities (hereafter called universities) to develop a comprehensive chemical management system:

- Highly decentralized chemical procurement and use pose challenges in devising an organization-wide chemical management program.
- Strong organizational inertia from chemical users to any reform or control on chemical management.

- Lack of information on chemical usage and related chemical management costs leads to underestimation of resources required for establishing a holistic chemical management program.
- Many universities are not familiar with available management approaches for establishing a holistic chemical management system because current chemical-related management activities are largely compliance-oriented focusing on end-of-pipe waste treatment (e.g. hazardous waste storage and disposal, and training on hazardous waste handling).

Overcoming these challenges will be critical to developing a successful comprehensive chemical management system - a system that must be supported by a robust information system, for tracking and managing chemical purchases, inventory, and waste handling and disposal. Improved data management not only facilitates compliance activities around chemical use and waste disposal, but also supports targeted activities like environmental preferable purchasing, waste exchange, and other waste minimization/pollution prevention programs.

The findings from the pilot with Dartmouth College and two other ongoing CMS pilots with University of California Merced and Stanford Linear Acceleration Center (SLAC) suggest that CMS could be a viable holistic solution for proper chemical management at universities. Dartmouth and SLAC are currently in the process of recruiting a CMS provider to assist them in developing a CMS Program. Their primary drivers for choosing a CMS approach include:

- Cash flow considerations: Upgrading an in-house chemical management system will require significant upfront costs to enhance internal capacity and develop a more sophisticated information system. Contracting with an external provider allows universities to pay an annual fee for a host of chemical management services instead of investing capital upfront.
- Cost effective approach for acquiring a best-in-class IT system: Experiences with other research institutions suggest that a comprehensive chemical information system - the backbone of a good chemical management system - requires continuous upgrades and, in some cases, a complete rebuild every 8-10 years. A CMS provider is able to conduct continuous upgrades of the IT system at lower cost due to the economies of scale with additional clients using a similar platform.
- Improve control over chemical acquisitions: A CMS provider can serve as the gatekeeper of a centralized chemical procurement and receiving system. Given that chemical procurement is highly decentralized at universities, the gatekeeper can help in consolidating chemical purchases to minimize redundant chemical acquisitions and tighten controls on hazardous materials review and approvals.
- Opportunities for waste and cost reduction and going beyond compliance: Better data on chemical purchase, inventory, and use can be used to design and implement environmentally preferable purchasing, chemical exchanges, and other waste minimization/pollution prevention initiatives.

- Reduce risk: An external CMS provider can help to reduce chemical inventory on-site, purchase less toxic chemicals, and address new heightened security requirements, thereby reducing the risk and liability to universities.

Although CMS is currently being considered by large, well-funded institutions, it is highly likely this approach could be applied in smaller institutions. The same challenges and drivers for considering CMS apply in the smaller institutions. Because CMS has not yet been applied in the educational and research setting, testing the CMS approach first in a larger setting will allow the CMS provider community an opportunity to develop and test their service offerings in this new sector. It is likely the CMS model will need to be adapted for smaller educational institutions to accommodate their lower chemical throughput. However, the needs are essentially the same for large and small educational institutions, so there is an opportunity for economies of scale for CMS providers to serve both. Finally, it will be important to demonstrate success of the CMS model in larger institutions to effectively appeal to smaller educational institutions.

INTRODUCTION

Colleges, universities, secondary schools, and research laboratories require chemicals for research, educational, custodial, and maintenance purposes. Chemical use is typically characterized by a high diversity of chemicals used in relatively small quantities by many users. Unlike manufacturing and industrial facilities, chemical procurement and usage is typically decentralized in education and research institutions. The organizational structure of universities and schools often involves many different departments making decisions with little oversight. The highly decentralized chemical use and the organizational structure of educational institutions make it extremely difficult for environmental health and safety professionals to track chemical flows through the institution effectively, i.e., purchase, use, inventories, and waste disposal. Regulators and emergency personnel are justifiably concerned over the risks of chemical use and waste management (or lack thereof) in educational settings.[1] Recent EPA enforcement initiatives focusing on colleges and universities found many violations showing the need for improvement in their management of chemicals. These enforcement actions have captured the attention of university presidents and deans who are struggling to find effective approaches to better manage chemicals.

In response to EPA's stepped-up actions, many universities and colleges are looking for chemical management approaches that can fulfill institutions' specific needs. The toxic nature of chemicals, together with the decentralized setting where professors enjoy considerable autonomy on chemical purchase and usage, poses particular challenges for institutions to properly manage chemical storage, usage, and disposal, i.e., their flow across the institution.

The Chemical Strategies Partnership (CSP) received funding from the United States Environmental Protection Agency, Office of Solid Waste (EPA/OSW) in 2002 to assess current practices and evaluate the viability of external chemical management service (CMS) companies to assist colleges and universities (hereafter called universities) in chemical management. A project with colleges and universities has greater transferability potential to the broader educational and research arenas. The specific objectives of this project are to:

- Develop at least two case studies on chemical management approaches used by colleges and universities.
- Recruit an institution to participate in a pilot exploring the use of CMS.
- Lay the groundwork for the pilot to explore whether a CMS program could more cost effectively facilitate chemical management, including the reduction and elimination of mercury, in a college or university setting. The actual pilot will occur as a second phase to this project.

A key question of this initial research is to determine whether an external CMS provider can provide value-added chemical management services more cost effectively than universities can by themselves. CMS is an emerging model in the manufacturing sector and is a proven "win-win-win" for chemical users, CMS providers, and the environment. This project seeks to

[1] For instance, several incidents of laboratory fires highlighted the challenges for fire fighting effort when the responding fire fighters had no information on what chemicals are stored in or around the laboratories.

determine whether CMS can enjoy similar success in educational institutions. Successful CMS programs are driven by strong information systems and pro-active management over the entire chemical lifecycle. CMS providers bring expertise and resources to their customers to drive down costs and waste.

To tackle chemical management, some universities have developed their own internal data systems and management processes. The appendices to this report look in-depth at two universities—The University of New Hampshire (UNH) and Dartmouth College. This final report synthesizes the broad findings from the two case studies and offers insights from other university programs we have discovered through the course of this project. We first provide an overview of common approaches universities have taken for chemical management. We then discuss common barriers to chemical management in the university setting, draw conclusions and make recommendations on how CMS can assist in overcoming these barriers. Note that Dartmouth College, which is committed to improve their existing chemical management system, intends to use the information from this case study to solicit bids from external CMS providers as a follow-up pilot project. Thus, this report represents exploratory research to evaluate whether the Chemical Management Services (CMS) model, which has been successfully utilized in the industry setting, may be applied to universities to improve chemical use efficiency, leading to a reduction in chemical consumption and waste generation.

The terms "chemical management", "chemical management system", and "chemical management services" can mean many things to many different people. For the purpose of this report we offer the following two definitions:

Chemical Management/Chemical Management System: These terms are used interchangeably in this report to refer to what universities are currently doing and can include a variety of activities and programs. Thus, a system to store material safety data sheets, waste exchange programs, making RCRA determinations, training and outreach, etc. are all elements of any universities' current chemical management system. The difference in the use of the terms CMS and "chemical management" is that the latter refers to what universities are currently doing and are largely designed and implemented by university staff.

Chemical Management Services (CMS): This term refers to having an external supplier or CMS provider play an active role in helping a university manage their chemicals. Some companies currently offer on-line management of material safety data sheets or manage individual stockrooms. However, to our knowledge, no university has a comprehensive CMS program where a single external CMS provider takes over the majority of informational, logistical and waste minimization activities for a university. CMS is distinguished by two features: 1) the use of external CMS companies, and 2) the CMS company provides a comprehensive program that encompasses all required elements of a "best practice" chemical management program.

I. What is CMS?

Chemical Management Services (CMS) is a business model in which a customer engages with a service provider in a strategic, long-term contract to supply and manage the customer's chemicals and related services.

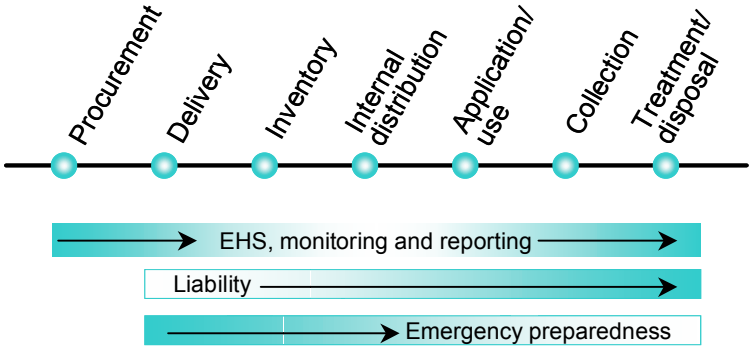
Traditionally, suppliers' profits are tied to chemical volume—the more chemicals sold the more profit generated. Under CMS, the providers' compensation is no longer based on volume, but on the quality and quantity of *services* delivered. This shift to chemical services often aligns the incentives of the supplier and their customer to reduce chemical use and costs. Results to date are impressive and indicate that the CMS model lowers total chemical costs, and both parties achieve bottom line benefits via reduced chemical use, costs, and waste. The CMS model is now widely used by large manufacturers in the automotive, aerospace and microelectronics sectors. It has demonstrated environmental benefits such as reduced chemical usage, reduced emissions of chemicals, reduced waste generation, as well as substantial cost savings with programs averaging between 30% and 50% total cost reduction in the first five years of program implementation. Many of these improvements are driven by the robust data tracking and information systems developed by CMS providers to actively manage a chemical over its lifecycle.

With CMS, chemical service providers offer a range of services across the chemical lifecyle (Figure 1). For example, a chemical service provider may purchase and deliver chemicals, manage inventory and MSDSs, provide data for environmental reports, research for chemical substitutes, and implement process efficiency improvements. This framework highlights total lifecycle costs of chemicals. Our research from manufacturing companies has shown that for each $1 spent on chemicals, companies incur anywhere between an additional $1-$10 to manage those chemicals. Financial incentives are included in supplier contracts for the chemical service provider to continuously reduce these management costs and reduce chemical use. In a more mature relationship the service provider is often paid a fixed fee for each product successfully produced (e.g., a fixed fee per 100 car doors painted or 1000 circuit boards cleaned). Thus, chemicals and related activities become a cost center which the supplier has an incentive to minimize.

CMS is far more than leveraged purchasing. It is focused on optimizing processes, continuously reducing chemical lifecycle costs and risk, and reducing environmental impact. More information on the CMS model and numerous case studies on the model and can be found at www.chemicalstrategies.org.

To evaluate the potential of this model in educational settings, we first provide an overview of how some universities are currently addressing chemical management challenges.

Figure 1: The Chemical Management Lifecycle



II. Current Chemical Management Practices in Universities

This section summarizes our understanding of the current chemical management practices in universities, based on desktop research, interviews with and site visits at the 2 case study universities, and programs in other universities that we become aware of over the course of recruiting organizations for case studies. Prior to recruitment, we have conducted desktop research to identify the types of chemical management initiatives implemented in universities, and which universities have implemented more innovative chemical management approaches. Our starting point for recruitment was universities known to CSP to have some form of improved chemical management system, or have expressed tentative interest in participating in this project. We have also participated and presented at two conferences for recruitment[2].

In total, we have interviewed 9 universities (including the two case study universities) and have also discussed with 5 universities about their chemical management practices at conferences. Additionally, we have conducted interviews with three chemical suppliers/chemical information suppliers, and with a non-profit organization (Campus Consortium for Environmental Excellence (C2E2)) that supports continued improvement of environmental performance in higher education.

Typical Characteristics of Chemical Management in Universities

Chemical-related management activities at universities follow the chemical lifecycle depicted in Figure 1. Our research points to several themes that are broadly applicable to the current state of chemical management in universities:

- ***Procurement***. Chemical procurement and use is complex, often involving hundreds of labs where chemicals are used and dozens of individuals who purchase chemicals. The

[2] For recruitment of pilot and case study partners, CSP participated in two conferences: the "Environmental Management System – The Next Generation" conference held at Massachusetts Institute of Technology in March 2002, and the Pollution Prevention / Green Chemistry Workshop held at Boston College in November 2002.

types of chemicals used in a university range from laboratory chemicals, to compressed gases, to fertilizer/pesticides, to janitorial and facility maintenance chemicals. Chemicals enter the universities through a variety of procurement pathways – credit cards, purchase orders, specific research projects and for regular teaching. The lack of a central "gatekeeping" point makes it nearly impossible to know what types of chemicals enter campus, in what quantities, and exactly where they are used and stored without constant auditing of chemical users and storage areas. This in turn poses substantial challenges for a university to understand and manage chemical-related risks and meet regulatory requirements.

- ***Receiving***. Some universities have established central receiving points for heavy chemical users, such as the Chemistry Department or the School of Science. However, it is still a common practice for suppliers to deliver chemicals directly to chemical users.
- ***Inventory/storage/internal distribution***. To ensure rapid and convenient access to chemicals, chemical users usually order chemicals and store them in their own laboratories / chemical storage areas. One drawback of such a practice is that unused chemicals often end up staying on shelves beyond their shelf life if there is no established system to encourage chemical transfer and exchange.
- ***Chemical use***. Chemical users are the one who determine what chemicals to use, and how much is needed. While profit (or cost reduction) is an effective motivating factor leading to system improvements for reduced chemical use in businesses, it is not as applicable in the university setting. As a faculty member pointed out, even though over-purchase of chemicals entails costs for chemical acquisition and incurs even higher costs for disposal, researchers seldom pay attention to optimizing chemical purchase. Likewise, some researchers prefer to maintain an extensive stock of chemicals for use whenever they need, despite the fact that such practice can easily generate long-staying chemicals that might present safety hazards, and costly disposal.
- ***Waste collection***. Pursuant to the Resource Conservation and Recovery Act (RCRA), universities typically store chemical waste temporarily at satellite accumulation areas (SAAs) near their point of generation, such as laboratories. Environmental Health and Safety (EHS) office is usually responsible for collection of chemical waste for centralized treatment. In some circumstances, EHS also prepares and delivers training on management of SAAs and conduct periodic inspections.
- ***Waste treatment and disposal***. EHS staff is typically responsible for managing chemical waste treatment and disposal. Many universities contact external vendors for off-site treatment of chemical waste.

Proactive Chemical Management Approaches

We have found that leading universities, who have taken a proactive approach and have some form of chemical management system in place, have followed two broad approaches:

1. **Internally developed system** - Several universities have developed full-blown programs internally that include most of the chemical management lifecycle stages such as, receiving, inventory, environment, health and safety (EHS), and disposal. These internal programs are usually developed and implemented through a mixture of the EHS department, the computer or information technology department, and

purchasing. Internal programs usually involve the development of an information system and various supporting measures (such as inventory audits) to track current and manage inventory and waste material. This can include requiring researchers, students and faculty to manually input chemical inventory data or it can include more sophisticated systems using computer bar code tags to track chemical containers. Several small universities are using commercial data management application, such as Microsoft Excel or Microsoft Access, to track and manage chemical inventory information.

2. **Internal program using external off-the-shelf information system** - Universities have purchased an off-the-shelf information system to track inventories and manage other EHS regulatory data, such as data for Tier II reports, and reporting requirement such as those found in OSHA and RCRA. These external systems still require processes for chemical users or EHS staff to manually input data or track containers using barcodes or Radio Frequency Identification (RFID) tags.

We have found once a university decides to better manage chemicals, they often will wrestle with the "internal" vs. "external" course of action. Of the dozen universities we came across during research, we found half of them developed programs internally while the other half relied to some extent on an external company for information technology. However, we have not yet come across any program that has taken a completely external approach similar to the CMS model. The quality and level of success varies greatly across the programs. Further, most programs struggled at the onset of implementing programs due to numerous barriers that are discussed in the next section.

Of the universities that developed internal programs, most initially explored external software solutions. Some universities tried an external information system that failed; others concluded that the external software packages on the market did not meet their unique needs or opted for developing a system in-house because the licensing fees became too costly. All noted that changing the behaviour of researchers and students who use chemicals in labs is critical for the success of any program whether it is using an internal or external information solution. Two universities, University of New Hampshire and Stanford, have developed information systems specific to their school and have sold or are in the process of selling software licenses to other schools, like Brown University and University of Massachusetts - Lowell.

Most universities who tried external software programs encountered significant up front challenges. Of the six schools we reviewed, two of them tried an external software package and ultimately abandoned it. Two other schools failed the first time but are implementing new management measures to engage the research and faculty community. Indeed, several schools noted that problems encountered are not due to any shortcomings with the software itself, but rather with the reluctance on the part of chemical users to use it. The final two have recently purchased new systems and have not fully implemented them at the time of this report. It should be noted that most of these schools considered external solutions three to five years ago. Several companies we have spoken with say their software packages have vastly improved.

Current Practices to Improve Chemical Management

In addition to the physical management and tracking of chemicals, universities are pursuing other programs that impact chemical purchasing or chemical use. For example, universities have followed the private sector in developing purchasing consortiums. In these consortiums, Universities aggregate their spend to achieve better prices on certain commodities. The primary goal here is to reduce the purchase price of chemicals but such consortiums can be a valuable, existing network to facilitate best chemical management practices across a consortium. Waste exchange programs are also a common approach to minimize waste.

Another effort that has been successful in reducing chemical use in the teaching area has been micro-scale laboratory techniques where the volume of chemicals for chemical experiments is greatly scaled down to use much less chemicals per laboratory exercise and student. In addition to reducing chemical use, micro-scale techniques greatly save on space in terms of storage of laboratory equipment and fitting more students into labs. While an innovative program, micro scale techniques occur independent of good or bad chemical management practices. Some universities are also proactively pursuing green chemistry – the design of chemical processes that reduce or eliminate the use and generation of toxic substances. The green chemistry approach is particularly effective in reducing use and toxicity of teaching chemicals.

In addition to discreet projects, a study sponsored by the Howard Hughes Medical Institute identifies 14 consensus best practices to managing hazardous waste in Universities. The impetus of the study was to look at a more performance-based approach for the application of RCRA over the existing methods to apply RCRA to laboratories (which was viewed as inefficient and difficult in the view of scientists, EH&S professionals and the National Research Council whom had earlier examined RCRA in the laboratory setting)[3]. They derived these best practices in a collaborative effort with ten universities and the report recommended applying a two tiered approach for applying RCRA to laboratories. First was to apply a performance-based model, using the 14 consensus best practices for guiding RCRA compliance in laboratories. The second tier promotes the university EHS departments to assume ownership and responsibility for laboratory waste and make the hazardous waste determination and any appropriate treatment on behalf of the academic institution.

In summary, comprehensive chemical management in universities is still in its early phases. As a whole, universities are at different stages of addressing chemical management needs and often spend years evaluating the best course of action. Many schools are struggling to determine how best to get their hands around a highly decentralized and complex system of purchasing, storage and use. In recruiting for the case studies, many schools were enthusiastic that EPA was researching better chemical management methods but past enforcement activities were still fresh in their minds. Thus, many were hesitant or refused to partake in this project

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[3] U.S.EPA Office of Solid Waste, *Evaluating the Consensus Best Practices Developed through the Howard Hughes Medical Institute's Collaborative Hazardous Waste Management Demonstration Project and the Need for Regulatory Changes to Carry Out Project Recommendations; Report to Congress*, March 2002.
< http://www.epa.gov/epaoswer/osw/specials/labwaste/r02008.pdf>

because they were unsure whether they were in compliance or not – an indication that many still do not have a handle on chemical management.

We believe the CMS model can facilitate the performance based regulatory approach recommended in the Howard Hughes study by implementing or facilitating the adoption of the 14 consensus best practices identified in the report. Further, external CMS providers can help design and implement discreet programs for chemicals such as waste exchanges, green purchasing policies, etc. Further discussion of potential benefits of the CMS model is given in the recommendation section of this report. The next section looks at specific barriers identified through our research and is followed by conclusions.

III. Barriers to Developing a Comprehensive Chemical Management System

There are a few significant barriers that Universities face whether they decide to develop a comprehensive chemical management system internally, purchase an external information system as part of their comprehensive internal program, or have an external chemical provider develop their comprehensive program.

Highly decentralized chemical procurement and use pose challenges in devising an organization-wide CM program. Individuals responsible for developing a system to ensure compliance with regulations are often immediately overwhelmed by how decentralized the institution's chemical procurement and use are and the vast number of users. Chemical purchases can be charged to department budgets or to specific research projects. The common use of credit card purchases adds additional challenges in capturing chemical procurement information. In fact, we have not met one organization (even those that have built their own systems) that can easily tell us what chemicals and how much they buy each year! Several states require extensive chemical inventory tracking. For example, in California, facilities must have a "map" of what chemicals reside in what buildings for fire code purposes. This presents an extremely difficult challenge when the purchase and delivery of chemicals is so decentralized. In addition, managing material safety data sheets (MSDSs) and implementing safety training also becomes difficult since chemicals are used in disperse settings with potentially thousands of users who typically own a large variety of chemicals. Such highly decentralized chemical procurement systems often lead to prolonged "evaluation" periods (sometimes years) with very little concrete action taken to improve the management of chemicals. In addition, even relatively small universities (such as universities with less than 5,000 students)[4] can have hundreds of labs making the initial clean-outs and audits a timely task that can also span years.

Organizational barriers persist even when a University decides on a course of action. There is strong organizational inertia from chemical users (academics and researchers) who see any form of chemical management or control over any aspect of the lab as stifling to research and innovation. It is still not clear how much of this inertia is real versus perceived by

[4] According to National Center for Education Statistics (2001), *Digest of Education Statistics*, about 78% of all degree granting universities enroll less than 5,000 students.
<http://nces.ed.gov/pubs2002/digest2001/tables/dt215.asp>

university EHS staff. We do know that it is a major challenge for universities to engage chemical users in laboratories to properly manage chemicals (e.g. properly dispose of expired chemicals) within their laboratories or to follow pre-approval requirements for toxic chemical purchases. As a result, many universities establish programs that follow the "path of least resistance" with some labs and researchers actively participating while others may not. In some programs that have been successful, EHS personnel may help or do audits, tagging containers, etc., to ensure all chemical containers are tracked. While costly, it lessens the burden on chemical users and ensures full participation. Thus, designing a "user friendly" system is critical for full participation and success. Some universities/laboratories have also streamlined EHS pre-approval process for hazardous chemicals (e.g. using purchasing software that automatically forwards purchase requests of hazardous chemicals to EHS for approval) to ensure timely chemical purchase while allowing EHS to control unnecessary purchase of toxic chemicals. Trying to get around organizational inertia can lead to a piecemeal approach to chemical management. Indeed, the survey by Howard Hughes points to universities that have many successful pieces to the puzzle. However, we have found that few universities have a comprehensive program that ties all the pieces together.

Universities underestimate required resources for CM programs: Since information on chemical usage within universities is often very poor, universities often underestimate the resources and management processes required for a successful chemical management program. CSP's cost analysis of Dartmouth University revealed that for each dollar spent on chemicals, Dartmouth spent an additional $1.40 to manage these chemicals. This cost may be higher after Dartmouth established a more comprehensive chemical management system that includes activities like tracking chemical acquisition and inventory, and facilitating chemical exchange. At some schools, attempts to institute a chemical management program often failed due to lack of internal resources devoted to the program. While implementing an information system is important, the training and engagement of researchers, faculty, maintenance staff and students to use the system will ultimately determine its success. Areas that are particularly resource-intensive include laboratory and storage cleanout of expired and waste chemicals, regular audits, and entering new inventory data in the system. Thus, developing an information system is an important part of the solution, but it can often give management a false sense of security that they have addressed chemical-related compliance problems. The responsibility of implementing the necessary procedures for audits and data entry often falls to an understaffed EHS department. Where we have seen successful internal CM programs, we have also seen the number of EHS staff substantially increase. Thus, for many universities who are still determining how to best meet chemical management challenges, any activity internal or external, will represent a cost increase above and beyond the purchase of an information system.

Universities are not familiar with available chemical management approaches: Most universities do not have a clear understanding of available management approaches for improving chemical management. At present, chemical related activities in many universities are still focusing on RCRA or OSHA compliance activities, such as laboratory safety, and hazardous waste identification, storage and disposal. Source reduction initiatives (like green chemistry, microscaling techniques and environmental preferable purchasing) and proper management of chemical inventory in laboratories or non-laboratory chemical storage areas are

largely voluntary. Universities are largely unaware of other successful programs and the ability of an emerging number of chemical management information systems. For instance, CMS and the use of external suppliers is still largely a foreign idea to most universities, despite its success in achieving environmental and economic benefits in the manufacturing and industrial sectors. Peer to peer exchanges have been the most successful way for EHS professionals to learn about options for chemical management approaches. Purchasing consortiums such as the one in the Northeast and the annual gathering of the University of California EHS directors can also offer an excellent forum for learning about new solutions.

IV. Conclusions

Our research points to numerous barriers and challenges facing universities (system complexity and organizational inertia, lack of resources to implement chemical management, lack of information on CM options) as well as a timely opportunity (strong demand for information with many schools still struggling with chemical management options). We draw some broad conclusions on chemical related issues below and make specific recommendations for the external CMS solution in the next section.

There are three key elements to an effective chemical management program. Whether a chemical management program is developed internally or with the use of external support, there are three four elements a program must have. This foundation will facilitate targeted activities like environmentally preferable purchasing, waste exchanges, and other waste minimization programs:

1. **Information systems that tracks inventory and trend data, and considers process or procedures for data entry and easy maintenance**

   Tracking chemical inventory and trend data. Any program must understand what chemicals are on campus, where they are and in what quantities, and track the waste generated from them. Most systems that we have researched, whether developed by a university like Stanford and UNH, or by a commercial company is focused on tracking chemicals in inventory and ensuring compliance with waste disposal. Such a snapshot is an enormous improvement over universities who only conduct annual / ad hoc inventory audits, or have no data system, but it often does not provide trend data that is needed for pollution prevention (P2) or waste minimization (procurement of chemicals over time, how long they are stored, who uses the most chemicals and which ones, etc.). While a good information system is the backbone to any program, most programs are initially geared towards compliance (e.g., they focus on chemicals after they are purchased, with data on existing inventory, chemical disposal, and hazardous waste generation, and do not usually track what is bought). This lack of a systems view limits P2 and waste minimization efforts which often lead to resource savings, and reduced management cost along the entire chemical lifecycle.

   Data entry procedures. Data entry for universities pose unique challenges given the highly decentralized structure, high number of chemical users and high turnover rate

that brings in new students and researchers each year. Programs that try to get each person who orders a chemical to input data (researchers, professors, maintenance staff, and students) have had significant challenges to get full participation. Our research suggests that several organizations have focused on the information system element and later struggled with getting data into the system. The growing popularity of credit-card purchases at universities has made it increasingly difficult to track chemical acquisition. A successful program must facilitate data entry through user friendly features. For example, instead of many users bearing responsibility for manual data entry, universities can adopt more expensive options include computer tags or the use of handheld computers to input chemical inventory and waste data in a more centralized manner. Many successful chemical management systems have tried to capture chemical procurement and inventory information by setting up centralized receiving places, where information of chemicals purchased is entered into the centralized system before chemicals are dispatched to individual chemical users. However, for large universities with numerous laboratories, located in cities with high turnover of courier delivery staff, it might not be feasible to set up a centralized receiving system.

2. **Periodic inventory audits and waste management**. To keep inventory data current, a system that monitors chemicals when they enter or leave individual lab inventories or maintenance storage areas must be put in place. As mentioned above, user-friendly data entry procedures can help to update chemical inventory as new chemicals enter laboratories or maintenance storage areas. As waste is generated, individual labs and other waste generating areas must coordinate with the EHS function to pick up waste, often store in accumulation areas, identify the waste and manage its disposal. Tracking waste disposal can be accomplished in real time with data systems and manual or electronic data input or with periodic audits. Note that lab cleanouts and initial audits serve as an existing baseline of chemical inventory. It is a significant up-front effort that universities must perform prior to implementing any type of chemical management.

3. **A strong education and communication plan**. For any chemical management system, engagement of chemical users/researchers is important since they are the ones who ultimately decide the type of chemicals to acquire and the quantity of chemicals needed, and manage chemicals in laboratory and chemical storage areas. Improved chemical management will require education, outreach and new procedures to get users to adopt the new system and change their old way of selecting chemicals, proper storing chemicals, and, if needed, continuously maintaining chemical inventory.

There is no single solution for all universities and schools. CM needs are strongly affected by the setting of individual universities: the complexity of chemical use, the university's organizational structure, its size and location, whether they are primarily research or teaching or a combination of both, etc. For instance, smaller universities with a limited number of chemical users, or have low volume of chemical use have found that simple database system (e.g. Excel or Access) can fulfill their needs for chemical inventory management. The number of chemical users and labs also makes it manageable to educate chemical users and get them to participate in the program. For large universities, a more complex system that can coordinate

different lifecycle stages of chemical management (inventory, storage, and disposal) may be required, so that EHS can have centralized information on chemicals and be able to design chemical use reduction or waste reduction programs. Most universities must decide whether building internal data systems and developing new protocols can most effectively meet their needs or whether data systems and some activities can be performed by external CMS companies. Universities must balance organizational and political factors, cost and the effectiveness of the system. The Howard Hughes study identified 14 best practices with universities having differing levels of implementation across these 14 practices. We see the three elements in the first conclusion as building blocks to implement many of these best practices and discuss how an external CMS provider can facilitate adoption of these practices across a chemicals lifecycle in the recommendation section of the report.

Universities must consider stakeholders when designing the chemical management system. Any new chemical management system will represent a fundamental change and require changes in the current way of procuring and using chemicals. It is critical that all stakeholders understand why the program is necessary, what it entails and what their role will be. These stakeholders include:

- *Chemical users* (researchers, teachers, students, maintenance staff). Many chemical information systems failed because chemical users were not interested in using the system, or did not use it properly. Many people are used to the current way of purchasing and managing chemicals and see any type of management or change as a threat to innovation, research and autonomy. Newer faculty generally are much more receptive to changes in procedures that must accompany a new chemical management program. A good chemical management system has to be designed in a way not to overburden chemical users with additional tasks. For example, UNH's system is designed to require minimal inputs from researchers, while providing added value to their operations (e.g. users can easily check a surplus chemical list for available chemicals already on campus).
- *Top management support.* Since an improved chemical management program impacts departments campus wide, successful programs need top management support to secure the up-front resources to develop the system as well as facilitate the implementation and active participation of various stakeholders.
- *The EHS staff who typically manage the chemical management program.* If a university is currently doing little in regard to chemical management, a new or expanded program represents new activities and a higher level of service than the status quo. Additional resources will then be critical to the success of any program. In addition to EHS, procurement and the IT department play critical roles in making new chemical management programs run smoothly. If the burden is put solely on the EHS function, EHS can be quickly overwhelmed trying to initiate substantial change across numerous departments. Resources for education and outreach to get users to adopt the system and change their original way of buying and storing chemicals proved to be critical for improving chemical management in the university setting.

EHS Directors need to use a value-based rationale to acquire the resources to pay for a new system. Successfully making the case for additional resources to improve and update an institution's chemical management system is a necessary first step. The threat of non-

compliance is the major driver to invest in a new system and in some cases, regulatory action has compelled the institution to act. Paying for chemical management largely remains an overhead cost to the university. Therefore, EHS directors need more sophisticated tools for making the case for improved systems and tracking value to the institutions for such improvements. Innovative funding mechanisms are emerging from the private sector and in some universities such as including an upfront chemical management fee attached to any chemical purchase and charge backs for waste disposal for users.

The above conclusions point to the unique and complex nature of chemical procurement, use and risks in the university setting. We believe that there is tremendous opportunity for CMS to be a cost-effective solution for universities and can be rapidly deployed in the college and university sector to better manage chemicals and achieve other environmental goals.

V. Recommendations

How exactly can an external CMS provider help academic institutions improve their overall chemical management? We list major lifecycle stages from figure one and provide examples of activities a CMS provider could perform. Recall a fundamental principal of CMS is that the CMS provider and the academic institution become partners in this effort; the CMS provider brings its expertise to the table and drives innovation by designing programs/best practices and helping to implement them. We have compressed the lifecycle of a chemical into five stages:

Procurement. A CMS provider can quickly get a handle on what chemicals are entering the campus through information systems and through procedures to centralize the procurement function. As mentioned previously, not one university we talked to could easily roll up their annual chemical purchases. CMS providers often serve as a "gatekeeper" where they execute the purchasing requests. For example, purchasing requests come through the CMS provider and they receive the inventory before different chemicals are delivered to individual departments, storerooms or labs. Note that chemical users (researchers, faculty, maintenance personnel) still decide which chemicals to use but the CMS provider helps this process and often can make it easier through on-line catalogues and the ability to check the progress of their orders. Such a gatekeeper function has proven to assist manufacturers using the CMS model to establish target toxic chemicals for reduction and alerting chemical users if they try to order such chemicals, to replace chemicals with less toxic alternatives, to ensure proper MSDS management, and to facilitate green purchasing initiatives. CMS providers can also manage the more mundane aspects of supplier relations such as rectifying problems with orders or expediting deliveries.

We have seen some information systems provided by CMS providers that have a central chemical requisition page connecting to the chemical suppliers' web pages and/or the procurement department. Information of chemical orders is captured at the time users enter their order through the central chemical requisition page. CMS providers therefore have the capability to assist universities to set up chemical information systems that include chemical procurement.

Delivery and inventory: A CMS provider will often set up a central receiving area to verify the proper shipment and to log the reception of chemical into a central data base. They are then responsible for safely delivering chemicals to the appropriate store rooms or laboratories. This facilitates challenges all universities face by ensuring chemicals are logged into the data system and takes this burden away from individual chemical users or EHS staff. Another value added element a CMS provider can bring to a program is to establish "just-in-time" inventory practices that have been a successful waste minimization strategy in industry by eliminating "over stocked" chemicals that ultimately get thrown away. Finally, CMS providers can interact with suppliers to change packaging and possibly the chemical volume of certain chemical containers so that only the amount needed is purchased.

Chemical Use: Given the highly decentralized nature of chemical use, it is unlikely that a CMS provider would have much responsibility over the use phase. However, they can help design and educate users on pollution prevention techniques or help launch initiatives that lead to reduced chemical use such as micro-scale techniques or safer alternatives e.g. non-mercury containing devices, environmentally benign cleaning products. CMS providers can also design and/or deliver trainings on proper chemical use and storage, e.g. proper labelling, proper chemical storage. In industrial settings, CMS providers have helped in industrial support functions such as waste water treatment and on-site power generation. To the extent that universities have these types of operations, many of the successes in the industrial sector could likely be replicated.

Collection/waste determination/disposal: External CMS providers can facilitate much of the compliance issues with RCRA waste and, more importantly, establish waste minimization strategies that go beyond the regulations. They can educate/train chemical users on waste accumulation, establish protocols to label waste, treat waste, collect waste, and manage satellite accumulation areas, and facilitate the EHS department or chemical users on making RCRA determinations. A CMS provider can also assess if permits are needed or should be obtained for any on-site treatment. In going beyond compliance, a CMS provider can establish waste exchanges and assist in the development of an environment management system.

Monitoring/reporting: Many of the improvements a CMS provider can offer are driven by robust information systems. Thus, many CMS providers can easily gather the data and design reports for regulatory compliance reporting. The real value of these systems is the reports that allow the CMS provider, in cooperation with the university, to track and understand chemical use and disposal, or their flow across campus from procurement to disposal. This information helps to identify areas of opportunities to promote improvement projects at different stages of a chemical's lifecycle.

Would CMS be an effective option for academic institutions?

The findings from the pilot with Dartmouth College and two other ongoing CMS pilots with University of California Merced and Stanford Linear Acceleration Center (SLAC) suggest that CMS could be a viable holistic solution for proper chemical management at universities. Dartmouth and SLAC are currently in the process of recruiting a CMS provider to assist them in developing a CMS Program. Their primary drivers for choosing a CMS approach include:

- Cash flow considerations: Upgrading an in-house chemical management system will require significant upfront costs to enhance internal capacity and develop a more sophisticated information system. Contracting with an external provider allows universities to pay an annual fee for a host of chemical management services instead of investing capital upfront.
- Cost effective approach for acquiring a best-in-class IT system: Experiences with other research institutions suggest that a comprehensive chemical information system - the backbone of a good chemical management system - requires continuous upgrades and, in some cases, a complete rebuild every 8-10 years. A CMS provider is able to conduct continuous upgrades of the IT system at lower cost due to the economies of scale with additional clients using a similar platform.
- Improve control over chemical acquisitions: A CMS provider can serve as the gatekeeper of a centralized chemical procurement and receiving system. Given that chemical procurement is highly decentralized at universities, the gatekeeper can help in consolidating chemical purchases to minimize redundant chemical acquisitions and tighten controls on hazardous materials review and approvals.
- Opportunities for waste and cost reduction and going beyond compliance: Better data on chemical purchase, inventory, and use can be used to design and implement environmentally preferable purchasing, chemical exchanges, and other waste minimization/pollution prevention initiatives.
- Reduce risk: An external CMS provider can help to reduce chemical inventory on-site, purchase less toxic chemicals, and address new heightened security requirements, thereby reducing the risk and liability to universities.

Although CMS is currently being considered by large, well-funded institutions, it is highly likely this approach could be applied in smaller colleges and research facilities. The same challenges and drivers for considering CMS apply in the smaller institutions. Because CMS has not yet been applied in the educational and research sector, testing the CMS approach first in a larger setting will allow the CMS provider community an opportunity to develop and test their service offerings in this new sector. It is likely the CMS model will need to be adapted for smaller educational institutions to accommodate their lower chemical throughput. However, the needs are essentially the same for large and small educational institutions, so there is an opportunity for economies of scale for CMS providers to serve both. Finally, it will be important to demonstrate success of the CMS model in larger institutions to effectively appeal to smaller educational institutions.

Advance CMS in the Education/Research Setting

The following four recommendations are designed to test CMS as a cost-effective option for universities to procure, use and manage chemicals. Given the strong positive reactions from both institutions and suppliers to date, more "complete" work to empower the institutions and establish supplier capacity is needed.

1. **Further information on successful approaches is needed**

   Most universities do not have a clear understanding of available management approaches for improving chemical management. Universities are also largely unaware of other successful programs and the ability of an emerging number of chemical management information systems. In the course of recruiting case study organizations for this project, we found organizations hungry for information to help them determine the best course of action they can take. Since many universities are still assessing or struggling with how best to comply with regulations and manage associated risks, this research is also timely. While the Howard Hughes report is valuable in identifying and providing examples of 14 best practices, its intent was not to assist organizations on how best to implement them and focused on best practices largely designed and implemented by the universities themselves. This report is a good start to explore how external contractors or companies can assist universities.

   We recommend a comprehensive overview that builds off this report to more completely identify approaches other institutions have taken, including the use or building of information systems, the project XL reports from New England universities, as well as other case studies from successful Universities. The information must describe how successful programs were designed, the resources required, the major barriers faced, and the outcomes achieved.

2. **Pilot the CMS model to test the effectiveness of the model and test the market**

   While the objectives of this pilot stopped short of testing the CMS provider market (in terms of the service level and cost CMS providers can offer), we intend to assist Dartmouth College through a request for proposals and bid evaluation phase. The pilot project with Dartmouth College can see how well a CMS can help education institutions to optimize chemical use, eliminate unwanted chemicals like mercury, and minimize waste generation. Given the wide variety of university settings, we recommend several other pilots to test the model in different contexts (size, mix of education and research, etc.). CSP's work in the manufacturing sector has shown that it is critical to prove the CMS model in the field and point to successes.

3. **Education, Outreach, and Dissemination of Tools to Assist Colleges and Universities to Adopt CMS**

   Once pilots are underway and have been monitored, targeted education and outreach will be required to further raise awareness and promote the CMS model. Our experience in promoting this model in the electronics, transport and metal working sectors indicates primary education through case studies, reports, "frequently asked questions" sheets and guidance manuals are a critical first step. Workshops that bring together universities who have programs, and CMS providers who can provide such services, is an effective venue for educating and empowering universities to develop their own CMS program. CSP holds an annual conference and has found that generally 40% of new attendees pursue a CMS program after attending. In 2002, a record 80% of new attendees are pursuing a CMS program subsequent to the conference. Universities can further benefit from CSP's manual, *Tools for Optimizing Chemical Management,* which can be easily modified to fit

the university context. Future workshops could feature case studies from the university pilots, including lessons learned and data on the costs and benefits of CMS. In addition, CSP will share general CMS principles and case studies.

4. **Nurture Supplier Capacity to Provide CMS**

   There is significant interest from the CMS provider community in serving universities as well as smaller industrial enterprises. To date, CSP is only aware of one or two suppliers serving the research sector. There are two precedents that are somewhat analogous to research settings. The first is the General Motors Technology Center, a sprawling 1 mile campus of research and testing labs that has had a CMS program for over 7 years. The second is at the Stanford Linear Accelerator Center (SLAC), a joint research facility of the Department of Energy and Stanford University. SLAC is in the midst of selecting a CMS provider after deliberating one year on whether to just look at information solutions. Like educational institutions generally, the economies of scale (in terms of volume of chemical purchased) are not present to make the traditional business case for CMS in these two cases. Thus, there is a need to work with the supplier community to understand the limitations they may have in serving the educational and research sector and begin developing more capacity within the supplier community. A supplier forum should be convened for existing or potential CMS providers that are interested in the educational and research sector. CSP has already identified at least six different companies who are interested and potentially capable of serving this sector. The objective of the CMS supplier forum would be to gather them with representatives of the research sector to learn about the unique challenges facing these institutions in implementing and funding a CMS program. The forum would look at options for program scope, value-based justifications for a CMS program, and alternative funding mechanisms. Additionally, the forum can evaluate the option of pooling chemical purchases of groups of small universities (like community colleges) into a CMS program to achieve economy of scale. This information would help suppliers begin to craft service offerings that are feasible for educational and research institutions to consider and implement.

The above recommendations aim to empower universities and colleges with information for considering CMS as an alternative tool to improve chemical management. The immediate goal of proposed future work in educational institutions is to improve chemical management, optimize chemical use, and enhance waste reduction in educational and research institutions through implementation of CMS programs. The overarching goal is bold — to transform the way in which educational institutions procure, use, and manage chemicals.

VI. **Appendices**: UNH Case study report, and Dartmouth baseline report