

# Designing a Low-Cost Pollution Prevention Plan to Pay Off at the University of Houston

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## ABSTRACT

The University of Houston is located just south of downtown Houston, TX. Many different chemical substances are used in scientific research and teaching activities throughout the campus. These activities generate a significant amount of waste materials that must be discarded as regulated hazardous waste per U.S. Environmental Protection Agency (EPA) rules. The Texas Commission on Environmental Quality (TCEQ) is the state regulatory agency that has enforcement authority for EPA hazardous waste rules in Texas. Currently, the University is classified as a large quantity generator and generates >1000 kg per month of hazardous waste. In addition, the University has experienced a major surge in research activities during the past several years, and overall the quantity of the hazardous waste generated has increased. The TCEQ requires large quantity generators to prepare a 5-yr Pollution Prevention (P2) Plan, which describes efforts to eliminate or minimize the amount of hazardous waste generated. This paper addresses the design and development of a low-cost P2 plan with minimal implementation obstacles and strong payoff potentials for the University. The projects identified can be implemented with existing University staff resources. This benefits the University by enhancing its environmental compliance efforts, and the disposal cost savings can be used for other purposes. Other educational institutions may benefit by undertaking a similar process.

## INTRODUCTION

The University of Houston campus covers ~550 acres and includes >100 buildings. Current enrollment is >35,000 students with ~5000 faculty and staff.<sup>1</sup> There are >400

laboratories on campus presently with more planned in 2006.

Colleges and universities typically generate a wide range of chemical waste and, because of their decentralized organizational structure face, challenges in complying with applicable waste regulations.<sup>2,3</sup> One of the critical functions of the University's Environmental Health and Risk Management Department (EHRM) is to manage chemical waste in accordance with the U.S. Environmental Protection Agency (EPA) and Texas Commission on Environmental Quality (TCEQ) rules.<sup>4,5</sup> This is a sizable undertaking for the EHRM staff and ties up many resources. There is no formal long-term investment in waste disposal costs for the University other than a demonstration of regulatory compliance.<sup>6</sup> Therefore, it is in the best interest of the University to minimize the quantity of chemical waste generated whenever possible so that funds could be spent on projects other than waste disposal.

In addition, the TCEQ has promulgated rules that require large-quantity hazardous waste generators, such as the University, to develop a written 5-yr Pollution Prevention (P2) Plan.<sup>7,8</sup> In these plans, generators describe the actions planned to minimize or eliminate the generation of hazardous waste at their facilities.<sup>7</sup> Previous P2 plans submitted by the University, as required by the regulations, had limited success in reducing wastes. The implementation of a more effective plan maximizing the available staff resources was needed.

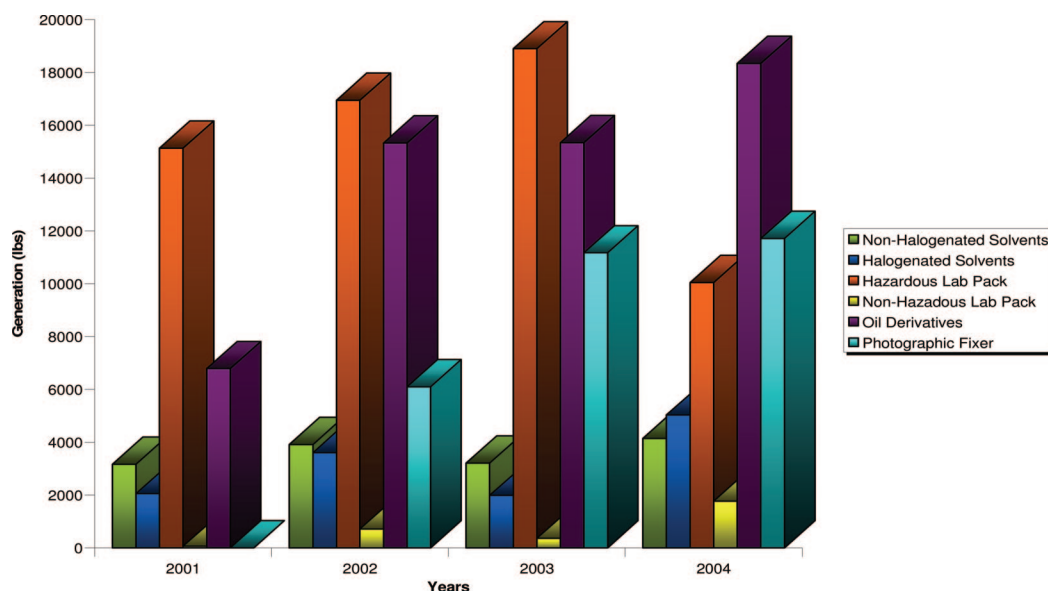
## Previous P2 Plan

The previous P2 Plan at the University of Houston was designed for the period of 2001–2005. This plan proposed goals to reduce or minimize hazardous waste by taking several steps.<sup>9</sup> These steps included the following: (1) chemical substitution: replacing a nonhazardous or less-hazardous substance for a hazardous or regulated chemical; (2) small-scale experimentation: scaling down the experimental techniques used in research or instructional laboratories; (3) chemical exchange program: instituting a CHEM-SWAP program for laboratories to trade their unused or reusable chemicals with other laboratories on campus; and (4) procurement initiatives: the EHRM petitioned the Purchasing Department to adopt a no-purchase policy for mercury-containing equipment and lead-based paint; historically mercury waste has been generated at the campus along with lead-based paint waste.

The University had some modest success with the previous P2 Plan. However, as the level of research has

## IMPLICATIONS

There is regulatory and economic pressure on educational institutions to reduce the amount of EPA-defined hazardous waste generated at their campuses. Although reducing and/or eliminating hazardous waste generation is a good management practice, institutions may face challenges in implementing this practice. These could arise from an increase in educational activities on campus or limited internal resources to implement new waste management initiatives. Regardless, a review of the current waste generation and disposal practices of the institution should be a priority. It is likely that waste reduction projects with attractive payoffs, which can be implemented with existing resources, will be identified.



**Figure 1.** University of Houston waste streams generation profile from 2001 to 2004.

grown 400% during the years 2000–2005, the overall total quantity of waste generated continued to grow.<sup>10</sup> In the year 2001, the University generated 30 t of waste, and by 2004 the total was 38 t. The EHRM expects that by implementing a more systematic review of the generating patterns of the University, a more effective P2 plan can be developed with minimal costs and without increasing staff.

### DESIGNING A LOW-COST YET EFFECTIVE P2 PLAN

The first stage of the plan development was to form a waste minimization team. The team was selected from the EHRM and then asked to follow a three-step process to identify potential projects. These steps included a review of the current waste generation profile, peer institution contacts, and identification of likely successful projects. Likely successful projects were defined as those that could be implemented with a fast payoff, such as  $\leq 12$  months, and with the existing manpower of the EHRM.

#### Review of Current Waste Generation Profile

The team then reviewed the annual waste summaries for the years 2001–2004. These are required reports for regulated waste per the TCEQ rules.<sup>5</sup> Figure 1 is representative of the waste generation of the University for the period of 2001–2004. The top six waste streams by quantity were waste oil derivatives, used photographic fixer, spent halogenated solvents, spent nonhalogenated solvents, and both EPA-defined hazardous waste and nonhazardous laboratory overpack drums.<sup>11</sup> The associated disposal cost of these six waste streams is given in Table 1.

#### Peer Institution Contacts

The team then contacted several other educational institutions and inquired about their waste handling practices and facilities. The initial contacts were made via telephone. The primary objective of these telephone conversations was to review their successful waste minimization

practices and possibly identify those that could be implemented at the University of Houston.

A site visit was made to the University of Texas Health Science Center at Houston (UTHSC-H). This institution consists of six health-related schools and has >800 laboratories.<sup>12</sup> The team was briefed on successful waste minimization projects undertaken by the UTHSC-H Environmental Health and Safety Department and then was escorted on a tour of their waste facilities.

#### Identification of Likely Successful Projects

The final step in the process was for the team to identify likely successful projects based on the waste generating profile of the University and the peer institution contacts. Each potential project was analyzed for time requirements, equipment needed, safety precautions, cost and savings expectations, potential waste stream reduction, and regulatory compliance.<sup>13,14</sup> Projects with the greatest cost benefit and ease of implementation were given the highest ranking. Likely successful projects were considered as having a projected payoff of  $\leq 12$  months based on 2001–2004 waste generation data or being readily doable with existing EHRM staff.

**Table 1.** Top six waste streams generation and estimated disposal cost for 2004.

| Waste Stream            | Quantity Generated (lb) | Waste Disposal Cost (\$) |
|-------------------------|-------------------------|--------------------------|
| Nonhalogenated solvents | 4146                    | 651                      |
| Halogenated solvents    | 5030                    | 1580                     |
| Hazardous lab pack      | 1769                    | 328                      |
| Nonhazardous lab pack   | 10,046                  | 7890                     |
| Waste oil derivatives   | 18,343                  | 3411                     |
| Photographic fixer      | 11,713                  | 5018                     |
| Total                   | 51,047                  | 18,878                   |

Notes: Source—University of Houston 2004 Annual Waste Summary.<sup>11</sup>



**Figure 2.** Original flexible exhaust line (left), original fume hood configuration (center), and retrofitted fume hood—note modification to easily roll drum underneath for safe bulking (right).

The team considered many different waste minimization options for the six largest quantity streams. These included the following: (1) increase recycle of waste oil: expand existing program to include all recyclable oils on campus; (2) increase bulking of compatible liquid waste: safely combine as much compatible liquid waste in a single drum versus individual containers overpacked with absorbent material; (3) increase bulking of compatible solid wastes: safely combine as much compatible solid waste in a single drum versus individual containers overpacked with absorbent material; (4) install solvent recovery system for chlorinated solvent wastes: secure the equipment necessary to recover the hazardous constituents of the chlorinated solvent waste stream, making the remaining material nonhazardous; and (5) installation of a silver recovery system for photographic waste: a system designed to capture the silver in the photographic fixer, which makes the remaining liquid waste nonhazardous.

From this list of potential projects, three were chosen by the team with the expectation that a significant reduction in waste generation could be made with the resources available to the department. The selected projects were: (1) increase bulking of compatible liquid waste; (2) installation of a silver recovery system for photographic waste; and (3) increase recycle of waste oil.

## PROJECT DEVELOPMENT AND IMPLEMENTATION

### Increase Bulking of Compatible Liquid Waste

This project consists of safely bulking compatible liquid chemical wastes by combining individual containers into a single larger container, such as a 55-gal drum. Compatible liquid waste would be considered as being in the same classification according to the Department of Transportation Hazardous Materials table.<sup>15</sup> Successful bulking of more chemical waste would lead to a reduction in the quantity of laboratory overpack (lab pack) waste. A lab pack waste drum typically contains 14–16 individual bottles placed throughout the absorbent packing material. The entire drum is considered hazardous waste, although a significant percentage may be the packing material. By bulking compatible wastes whenever possible a significant reduction in the total quantity of lab pack waste could be achieved. The team estimated that this project

could reduce the cost of lab pack waste from \$8218 to \$569 per year. This would be a 93% cost savings.

The project would likely require an additional 8 hr per week of EHRM staff time to segregate chemicals according to their compatibility and bulk them into drums. A reassignment of duties for existing personnel could be made to accommodate the 8 hr. In addition, there is always a possibility of an unforeseen chemical reaction while bulking chemical waste. Historically, bulking was conducted under a flexible exhaust line in the waste facility. The team identified a method to facilitate safer bulking by moving the operation to a fume hood. This could be accomplished by retrofitting the hood at a cost of ~\$2307 dollars. Due to the savings potential of this project, the alterations were made to the fume hood. Figure 2 shows the modifications made to enhance the bulking process in the university waste facility.

### Installation of a Silver Recovery System for Photographic Waste

The photographic laboratories at the University of Houston generated a total of 6 t of liquid silver-containing waste in 2003 and 6.5 t in 2004. Silver is one of the primary components of film and photographic paper that make it possible to form an image. Although it is not an ingredient of the original photographic solution, it is a byproduct of the film and paper processing. Silver is a heavy metal and is considered a hazardous waste by EPA.<sup>4</sup> Discharge of silver to the City of Houston wastewater treatment system is strictly regulated.<sup>16</sup>

Silver has an economic value, and recovering it from the photographic waste saves the University money from two sources. First, the University receives a monetary value or credit for the silver recovered, and second, the University reduces the amount of hazardous photographic waste generated and the associated disposal cost.

Silver in the form of thiosulfates anionic complex can be removed from photographic processing solutions by a number of techniques including electrolytic recovery, metallic replacement, precipitation, and ion exchange.<sup>17,18</sup> The best alternative for the University is a combination of an electrolytic recovery system followed by a chemical recovery cartridge system. This combination will provide a higher

**Table 2.** Projected impact of the waste minimization program (6 largest waste streams).

| Major Waste Streams     | Quantity Generated Before (lb) | Projected Quantity Generation (lb) | Project         |
|-------------------------|--------------------------------|------------------------------------|-----------------|
| Nonhalogenated solvents | 4146                           | 5824                               | Bulking         |
| Halogenated solvents    | 5030                           | 14,558                             | Bulking         |
| Hazardous lab pack      | 1769                           | 518                                | Bulking         |
| Nonhazardous lab pack   | 10,046                         | 91                                 | Bulking         |
| Waste oil derivatives   | 18,343                         | 0                                  | Recycle         |
| Photographic fixer      | 11,713                         | 0                                  | Silver recovery |
| Total                   | 51,047                         | 20,991                             |                 |

Notes: Source—Expected waste reduction by implementing waste reduction projects: (1) bulking, (2) recycling, and (3) silver recovery.

silver recovery, allowing the remaining solution to be disposed into the city sewer system. The necessary equipment can be leased, and a vendor can service and maintain the silver recovery unit. The equipment lease, service, and maintenance cost is expected to be ~\$676/yr. There will be additional costs for setup and installation. This project is expected to reduce the cost of photographic fixer waste disposal from \$5018 to \$676/yr, an 87% savings.

The EHRM expects to eliminate ~11,713 lb of photographic waste per year with the addition of the new silver recovery unit. By using a lease service option, there will be minimal impact on staff requirements to service the unit.

### Increase Recycle of Waste Oil

One of the benefits of developing a systematic P2 plan for an institution is that it is possible to improve on existing recycling efforts that are already in place.<sup>5,19,20</sup> This was the case for the University in terms of used oil recycling. The University has a fleet of 139 assorted trucks and cars and also has an auto shop that performs routine maintenance on these vehicles. The auto shop has a used oil collection system with a pump, associated piping, and a 1000-gallon storage tank. The auto shop had an arrangement with a local used oil reclamation firm to have the tank pumped out on a regular basis at no cost.

The waste minimization team quickly realized that used oil from other parts of the University could be added with this oil. EHRM waste personnel could easily bring used oil collected on campus to the collection system and have it pumped to the storage tank. The impact on the EHRM staff would be minimal to implement this procedure. The team conducted a compliance check of the current vendor with the TCEQ and also visited the reclamation site. This project is expected to eliminate used oil disposal costs from \$3411 per year to \$0, a 100% savings.

### THE COST-BENEFIT ANALYSIS

Table 2 displays the potential impact of the new P2 plan. The table lists the total waste generated before the plan is implemented and the projected implementation quantities of the proposed projects.

Comprehensively, all of the projects combined could benefit the University in reducing the waste generated from the six largest waste streams from 51,047 lb per year

to 20,991 lb/yr. This will lead to a reduction in overall disposal costs.

The most significant remaining challenge is the reduction of unknown waste. Although the amount of unknown waste is minimal, the analytical expense to identify the waste and assure proper disposal is significant, greater than the collective disposal cost of the six largest waste streams. This challenge can be addressed by educating the laboratory personnel of the importance of waste identification and segregation.

Figure 3 demonstrates the University waste generation profile for the base years 2001–2005 and the predicted waste generation for the years of 2006–2010. The figure shows the projected waste reductions with the implementation of the three selected projects described previously. The forecast shows the elimination of the photographic fixer and waste oil derivatives streams. Lab pack waste also shows a very significant reduction. The halogenated and nonhalogenated solvents show an increase due to the shift from lab pack waste to bulked solvents. However, the increase in disposal costs for the bulked halogenated and nonhalogenated waste solvents is offset by the projected savings in lab pack waste disposal costs.

### CONCLUSIONS AND RECOMENDATIONS

The University of Houston is a large teaching and research institution that generates a significant amount of chemical waste that will likely increase as the University continues to grow. Much of the waste generated is considered hazardous per EPA regulations. The University faces increasing regulatory and economic pressure to reduce the amount of hazardous waste generated and the associated disposal costs. The EHRM has had modest success in the past in reducing hazardous waste generation; however, it faces staff and budget limitations. A more effective P2 Plan was necessary using the available departmental resources.

A waste minimization team was formed, and a three-step process to identify likely successful projects was followed. These steps consisted of profiling current waste generation processes, contacting peer institutions, and selection of projects. By following this process, the university has identified several projects and is expecting to reduce its six largest waste streams collectively by 50%. Furthermore, the University expects to achieve these goals with its existing staff and also expects to pay the cost of implementation within the first 12 months of each project.

Waste minimization is a long-established environmental and economic best practice. The University has faced challenges in trying to reduce waste generation with the available resources while at the same time experiencing growth. Other institutions and organizations may face similar challenges. The University has found that despite these challenges, an effective P2 Plan to minimize waste generation can be developed with the resources available to the organization. Such a P2 Plan can be surprisingly effective in reducing waste quantities and can be highly cost effective.

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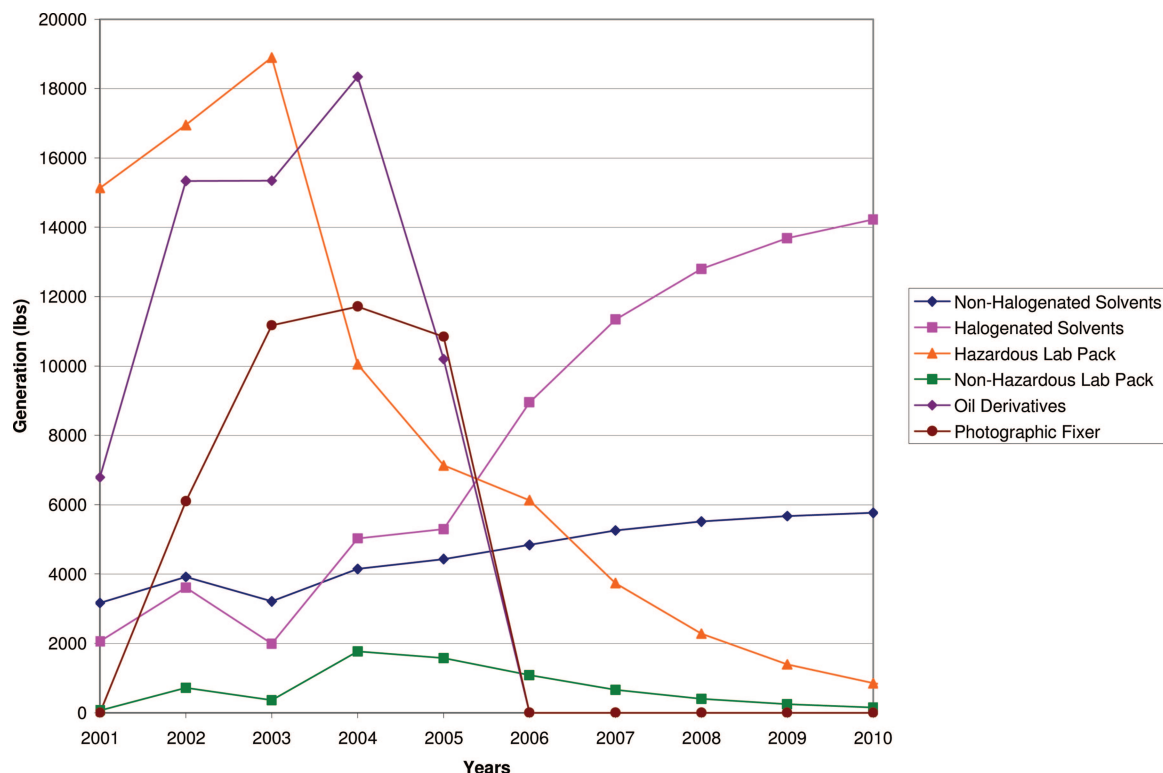


Figure 3. University of Houston major waste stream generation profile.

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