Surplus Chemical Exchange at Chulalongkorn University

http://www.chemistry.sc.chula.ac.th/SCECU

An Interactive Qualifying Project
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by

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AUTHORSHIP

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ABSTRACT

This project created a chemical exchange program at Chulalongkorn University. Research was conducted on exchange programs in the United States, and on the feasibility and success of an exchange in Thailand. The resulting program uses an electronic format to exchange surplus chemicals on the CU campus and can be easily expanded in the future. This program will help reduce the amount of chemical waste that is disposed of at CU.

EXECUTIVE SUMMARY

Thailand is facing rather serious health and pollution problems from improper disposal of chemical waste. Until recently, these problems have gone unchecked. Community members, especially within government, industry, and academia have now begun to take action. One step has been the creation of a laboratory surplus chemical exchange program at Chulalongkorn University (CU). The exchange was designed to be technologically, financially, and motivationally sustainable for the long term. It is planned to expand from CU to include more university, government, and commercial laboratories.

Several years ago the US faced similar issues concerning pollution. Citizen's concern brought stringent regulations on waste disposal. Costly fines led to the establishment of materials exchange programs in the United States. Academic institutions and government bodies sponsored such programs in response to increasing demand. A number of materials exchanges focus specifically on chemicals and hazardous wastes.

In one configuration, exchanges are run from a central facility where the shared substances are stored. An alternative is for an exchange to trade only information about the names and locations of surplus chemicals. The staff of these programs might only display a list of donated materials to its users, or actively promote its use.

Using information from US exchanges as a foundation, this project assessed the available facilities and prevailing attitudes at Chulalongkorn

University to create a viable system for that institution. This assessment included specific details from interviews and surveys as to how the exchange should be designed.

CU does not currently have the capability to store all the materials that could be traded on the exchange, nor has it the equipment to recycle byproducts or used solvents. However, there are ample computer facilities on campus making Internet access widely available. This availability suggested the creation of a web-based exchange. Implementation of this system was planned for in four phases. It was decided that the first stage should be non-profit and include only the CU campus. A web page was created, allowing Internet users to contribute surplus chemicals by providing necessary information electronically. A list is then compiled containing this information and displayed on the SCECU web site. Participants are then able to search for any chemicals they wish to obtain. Acquisition is handled outside of the exchange through direct contact between the donor and interested party. Expansion in three additional phases will increase the capabilities of the web site. Additionally, the exchange will extend its range of participants and actively promote its services to government and industry.

Studies probing the probable success of the exchange had mixed results. There are some indications that instructors will not be compelled to recycle their chemicals. Chemical waste management is not standardized at CU, so some students dispose of chemicals improperly. This practice suggests a lack of attentiveness among CU professors and students to the effects of chemical pollution. All parties felt that they were environmentally aware, regardless of their disposal practices.

On the other hand, the surplus chemicals found on shelves throughout CU indicated a definite need for a chemical exchange. Staff and students supported the idea of such a program and contact with industry and government authorities revealed added enthusiasm for its possible success. These conclusions indicate that the exchange will have a lasting effect at Chulalongkorn University. Ultimately, it will assist Thailand to maintain a sustainable industry, improving human health and environmental quality.

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CHAPTER 1: INTRODUCTION

The past few decades have proven to be a truly productive time for Thailand. Increased prosperity and educational advancements have provided the country with a boost in industrial development. As a result of this expansion, large amounts of waste have been, and continue to be, produced. Laws regarding the disposal of this waste were created, but a lack of enforcement has allowed for widespread illegal dumping. Inadequate disposal methods have resulted in disasters ranging from food and water contamination to chemically induced explosions. These circumstances have increased awareness of and ethical concern for human health and environmental preservation.

At Chulalongkorn University (CU), the Faculty of Science has responded to these concerns with several campaigns for chemical waste management. This document reports on one such initiative to reduce and reuse chemicals at CU.

The ultimate goal of this project was to provide CU with a feasible and effective exchange program to facilitate the use surplus chemicals which otherwise would have been disposed of. Requirements for this program were that it be technically, financially, and motivationally sustainable in the future. The exchange was also designed to eventually encompass other Thai universities, government laboratories, and commercial facilities. For the industrial sector and universities alike, reduction in waste streams will mean a decrease in expensive chemical acquisition and disposal costs. Ideally, a successful program will address the ethical concerns of human health hazards and environmental degradation.

In order to produce the best possible program for CU, a variety of human behaviors and material factors were studied, making this assignment well suited as an Interactive Qualifying Project. Investigations of motivations and attitudes of professionals involved with chemicals and chemical waste were completed. These examinations were done through a variety of means including interviews and surveys.

The report itself is intended for use by chemical waste generators and consumers, those interested in designing their own waste exchange program, and anyone interested in reducing chemical pollution. This report should give the reader an understanding of the design and organization of a materials exchange.

Environmental problems in Thailand and the responses of CU are introduced this chapter. Chapter 2 describes current U.S. problems and practices pertaining to chemical pollution and illustrates the increasingly attractive option of waste exchange. Interviews were conducted to provide basic information such as customary operating procedures and details about materials shared on the exchanges. These findings aided in the understanding of the managerial and financial workings of a successful exchange. In addition, the results of research about Thai attitudes about the environmental, and the economic situation in Thailand, are discussed.

The methods used to gather information for our report are detailed in Chapter 3, wherein the project statement is given, followed by a listing of the necessary steps to decide what would be an effective program for CU.

The results compiled in Chapter 4 include current waste practices, regulations, and enforcement in Thailand. Also discussed were Thai interpretations of existing laws and an examination of common attitudes towards safety, future plans for chemical management at CU, and details of the computer accessibility on campus.

This information is utilized in Chapter 5 to make conclusions about the form that the proposed exchange should take. The actual proposals and implementation are presented in Chapter 6 where a four-phase plan is described in detail. Chapter 7 provides a project overview and is followed by Chapter 8 which contains an annotated bibliography sorted by subject.

As a whole, this paper identifies and discusses the problems of chemical waste management at Chulalongkorn University and proposes a potential solution to be used at CU as well as other Thai institutions.

CHAPTER 2: BACKGROUND

The purpose of this section is to provide the reader with an adequate understanding of North American chemical exchanges. This includes a base knowledge of those US chemical pollution problems that made the exchange a viable innovation. Also contained within the text are functional details of material exchanges such as how selected programs were implemented, what substances are used, how they are organized, and what efforts are made towards promotion and funding. Following these sections is a discussion of Thai behavior in relation to national economic and environmental problems.

2.1 US CHEMICAL WASTE PROBLEMS AND SOLUTIONS

Several decades ago, the US faced the same dilemmas that Thailand and other developing countries are currently facing regarding chemical waste disposal practices. People began to see the health risks associated with chemically contaminated food and water supplies. Environmental worries arose regarding deforestation, deterioration of farmlands, and waste related degradation of marine life. In addition, economic predicaments arose from high health care and cleanup costs.

Due to tireless grassroots lobbying, the US Congress passed a series of laws encouraging manufacturers to cut the quantity of hazardous waste they produce. Additional responses came from the EPA and DOT, mandating improved hazardous waste practices through strict requirements for handling, transportation and disposal. These stringent regulations spanned the industrial sector and university campuses penalizing with high fines those not in compliance. Informational materials were made available to educate generators on ways to comply with the new rules. US EPA regulations for handling hazardous materials are outlined later.

In the US, the owner of a chemical is considered to be responsible for its proper disposal or transferal. This philosophy was enforced by the implementation of cradle-to-grave responsibility, which mandated that the owner possess a record of the identity of a chemical's next responsible party for five years after transferal. Because of government regulations, disposal costs went up, as did treatment and transportation fees. The majority of hazardous chemical wastes were incinerated or placed in landfills, which are costly processes. For instance, prices for the disposal of a 55-gallon drum of paint reached up to US$800 (Messier, 1999). Since exchanging materials was much less expensive than disposal, material exchanges became a safe and economical choice for generators.

High prices gave rise to other waste minimization solutions. Both academia and industry began decreasing waste quantities by practicing better inventory control. Also, academic institutions introduced *microscale* procedures into teaching and research laboratories in order to decrease the volume of wastes produced. Solvent recycling became more widely utilized as well. Additionally, industry began to substitute harmful substances and processes with those less dangerous. One further approach to waste reduction is the increasingly viable chemical exchange, the focus of this report.

2.2 *DEFINITION OF EXCHANGES AND CHEMICAL WASTE*

In short, a materials exchange facilitates the reuse of substances that otherwise might have been disposed of. The wastes of one laboratory or manufacturing process can become the raw materials for another. This exchange results in a mutually beneficial situation for both parties because purchase and disposal costs in an environmentally conscious manner (RCBC Reiterate, 1996). An exchange of reusable or surplus chemicals, or a *chemical waste exchange,* as it is usually referred to in the US, is a small, specific corner of the large arena of materials exchange.

Exchanges have the function of advertising available compounds and promoting communication between chemical generators and acceptors. While some exchanges are privately owned companies, most are controlled by larger organizations, such as corporations, the government, or universities. *Corporate* and *government chemical exchanges* are usually a subsection of *materials exchange,* while *university chemical exchanges* are generally independent organizations and include only chemicals. Exchanges are set up and used primarily because of economic motivations but also for ethical reasons, such as concern for human health and the environment.

At this point, it is necessary to define some of the terms that will be used to refer to chemicals and their different relationships within an exchange. This paper categorizes substances as either *usable chemicals* or *chemical wastes.* Usable chemicals can be either surplus goods or recyclable substances. Surplus goods are those that are ordered and either left completely unopened or used partially and then put aside. Recyclable substances may be recovered solvents, acids and reaction byproducts. Determining the reusability of a material can be done through a number of purity testing methods. These testing methods as well as details regarding purification are discussed in greater detail in Appendix B.

Chemical waste includes a wide variety of materials, such as discarded commercial chemical products (DCCP), processed wastes, and wastewater. In addition to these, surplus goods that expire or become contaminated may be deemed waste. In general, all of these substances are materials that must be disposed of because they are either hazardous or unusable. Hazardous waste is a specific type of dispensable material waste that the EPA considers dangerous enough to warrant regulation. Waste is regulated in the US according to the Resource Conservation and Recovery Act (RCRA) of 1976 under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), and subsequent amendments to both (Appendix C). *Listed* and *Characteristic* are two ways of classifying hazardous waste. Listed waste defines the material by the process that created it. Characteristic waste is classified by the properties of a material. The details concerning the definition of hazardous wastes can be found in Appendix D.

Despite the name *chemical waste exchange* attached to the organizations located in the US, very few deal with waste as it has been defined above, so the term "chemical exchange" will be used henceforth. Currently, all exchange in the academic setting is done with usable compounds obtained from teaching and research labs, art departments, workshops and motor vehicle maintenance shops.

2.3 CREATION OF CHEMICAL EXCHANGES

As discussed in section 2.1, the creation and enforcement of disposal laws in the United States established the economic and ethical need for material exchanges in the academic and industrial sectors. Academic chemical exchanges may be introduced into the institution's system by a single individual or through a proposal to the administration.

Large universities typically generate, store and dispose of waste materials in quantities averaging 10-15,000 kg per year, making proper disposal extremely expensive. Health and safety departments spent up to US$250,000 per year for proper disposal. Further discussion of proper handling and disposal techniques can be found in Appendix A. Figures like this encourage those controlling tight academic budgets to find ways of cutting costs. Chemical exchanges become an option when they save the university more money then their operating costs. Dr. Elizabeth Griffith of the University of South Carolina estimates that between 1/3 and 1/2 of currently discarded wastes are usable and can be redistributed, saving the university an estimated US$150,000-200,000 per year, net.

Informal efforts initiated the majority of the chemical exchange programs currently in operation. Programs in five out of the six schools surveyed were set up by a member of the health and safety department simply because that person felt that it would be beneficial both environmentally and economically. After the idea materialized, starting was simply a matter of finding the space and time required for operation. Initiation costs were minimal as the necessary resources were already in place, so with the approval of the administration, time was taken from the staff's regular workload to establish the program.

In some circumstances, there was a need for permission to be granted by the school administration through a formal proposal from the health and safety department. In many cases, the health and safety staff office did not have the manpower to put together such a proposition. A few institutions, such as Duke University, made a proposal to the administration in the form of a graduate students Master's degree.

There are situations where academic exchange programs are necessary as well as desirable. The University of Berkeley at California, for instance, found itself subject to environmental laws concerning chemical waste. Code SP-14 of the California State environmental regulations requires that all generators exhibit yearly reduction in the volume of hazardous waste produced. Since a recycling program reduces the quantity of compounds that become wastes, chemical exchange helps generators comply with this code.

Programs evolve after their creation based on responses to the operation. At the University of South Carolina, the first version of the program was an exchange with a storage room in the main chemistry building in which exchangeable materials were collected. Unfortunately, the EPA began complaining that USC was circumventing the hazardous material's storage time limits and the storage area was eventually removed. However, packaging and transportation of exchange materials continued to be handled by employees of the Health and Safety Department. Eventually, the exchange administrators adopted an information-only system when questions concerning the responsibility of these employees were raised.

2.4 *OPERATION OF CHEMICAL EXCHANGES*

Chemical exchanges in the US, both industrial and academic, operate with either a centralized or bilateral system. A centralized program stores all materials in one location and the exchange personnel handle the substances involved. The usable substances are donated by researchers, or contributed by laboratories that have closed. Compounds are entered into an inventory, which is made available to interested parties. When a substance is requested by a teaching laboratory, research facility, or industrial organization, the container is pinpointed in the storage area and distributed (Portland State University, 1999).

Bilateral systems deal only with necessary trading information. The operator of the system obtains the material's name, quantity, purity, possible contaminants, and owner, then lists them in a database, which is distributed. The compound itself remains in the hands of the donor until another party requests it. Many exchanges do not distribute the donor's name because some researchers prefer the identity of the substances that they are using to remain confidential. In this case the exchange may transport a compound once it is requested. If the owner and contact information is included in the exchange's database, the request is made to the owner directly without involvement of the exchange.

The choice to operate an exchange with a bilateral or centralized system is dependent on the staff, facilities, and interests of the organization operating the exchange. Many academic exchanges are centralized because the storage space and the staff are available, thus simplifying the transactions. However, most industrial exchanges, especially those with little funding, prefer the less involved bilateral scheme. Bilateral exchanges have lower operating costs and less risk.

The University of Massachusetts at Amherst (UMass) has been running a centralized program for 12 years, managed by Jim Field, who is an employee of the Health and Safety Department there. The chemicals involved in the program are commercial compounds in unopened containers, including paint and cleaning agents. It occupies part of the temporary hazardous waste storage building. Donated substances come from supplies ordered by professors that for various reasons, such as time restrictions, or budget surpluses, were never used. When one of the 1200 labs on campus is closed, unopened containers are separated from wastes and entered into the electronic exchange inventory. All of the compounds currently available are found on the internet (UMass Amherst, 1999). The exchange does not charge for the materials or the services because all the substances are surpluses. The managers of the program note that the exchange is frequented more often when users are actively sought and when a paper version of the inventory is distributed regularly (Field, 12/17/99).

The University of South Carolina uses a bilateral exchange run by the Health and Safety Department. On a weekly basis, a letter is sent to all faculty members asking them to report all surplus materials. Purchasing orders are also reviewed to discover what compounds were recently acquired. The information acquired by these two sources is then compiled to create a database of all the substances available. Due to the security concerns mentioned above, the database is not available on the internet, nor is the name of the chemical donor made public. Once the database is compiled a copy is sent to all the staff and faculty. If there is a compound that a group is interested in, the exchange staff will pass on the name of the holder. The donor and the receiver are thus directly linked by the system, eliminating the need for a middleman. Unlike the UMass exchange, which swaps only unopened industrial compounds, USC's exchange involves all usable chemicals, both byproducts and surplus. USC's exchange is confined to the campus, however, and is not extended to the surrounding commercial communities (Raja, 17/12/99).

Chemicals from academic institutions and industry are very different and not typically swapped within the same exchange. However the two may be linked in a system called a hybrid exchange. Typically organized within a university, this sort of scheme may range from acceptance of limited commercial surplus goods to coordination of all exchangeable compounds in a large area.

The Portland State Chemical Consortium in Oregon, for instance, encompasses 72 parties within a 800 km radius, ranging from primary and secondary education facilities to local industry and small businesses. The exchange is a centralized system run by six employees and managed by the Health and Safety Administration of Portland State University. The program is housed in a facility on the outskirts of the university's campus, which accounts for a large portion of its operating costs. Membership fees, which are higher for industrial contributors than for smaller waste producers, provide an annual budget of US$6,000.

The UMass exchange can also be considered a hybrid program because its users do not have to be affiliated with UMass. Materials are frequently taken by researchers and organizations outside of UMass that found the substances by using the exchange's website. Donations are not accepted from outside sources because a *Treatment, Storage, and Disposal Facility (TSDF)* permit is required for storing other's chemicals before transferring them to another user. These permits are difficult to acquire and there are substantial penalties for operating without a permit (Fields, 17/12/99).

Brokerages are another operating scheme that are for-profit organizations which specialize in finding buyers for reusable substances. These organizations find a home for specific compounds and charge a standard fee or percentage of the transaction cost in return. The brokerage may buy the substance and resell it or act as a middleman between generator and buyer. For continuing transactions a long-term written contract is drawn up, guaranteeing payment to the broker. Most brokerages are bilateral, some take legal ownership of the material and leave it at the generator's site. They may even use other existing materials exchanges as the source of the goods that they buy and sell. Canadian Chemical Exchange (CCE) is one of many exchanges that do business by finding companies and processes that create and consume specialized materials (Industrial Waste Exchanges, 1996, Ch. 5).

CCE is a brokerage in Canada that usually takes ownership of the material and does not reveal the source to the buyer. It often finds its sources by using non-profit and government exchanges, such as the Ontario Waste Exchange. Transportation costs, chemical type and purity affect the profit gained, making CCE very selective in purchasing compounds for resale (Industrial Waste Exchanges, 1996, Ch. 2). It must avoid small, complex, highly contaminated wastes streams as well as materials that are inexpensive in their virgin form (Industrial Waste Exchanges, 1996, Ch. 5).

2.5 *PROMOTING EXCHANGES*

Promotion of an exchange may be proactive or passive. Proactive advertising techniques aggressively seek parties to participate in the exchange. Passive refers to a lack of active advertising, usually because of insufficient funds. The decision to adopt one of these methods is based on the size and financial situation of the exchange. A passive exchange can inexpensively announce its presence and exhibit its contents in catalogs, brochures, and web pages, relying heavily on customer initiative. A proactive exchange increases public awareness by seeking companies in need of services, matching generators and consumers, providing workshops, posting bulletins, and advertising.

Chemical exchanges run by academic institutions generally choose to be passive because usually they function only within the university. Their promotion typically consists of distributing lists of available materials within the school. In several instances, the exchange staff will seek a professor who might need a substance that they possess. Passive exchanges in the industrial sector match only 20% to 30% of the materials in their databases and must dispose of the remainder. Many transactions are missed because more time and effort is required than the passive exchange can expend (RCBC Reiterate, 1996).

The *California Waste Exchange (CWE)* has been part of the California Department of Toxic Substances Control since 1976. Most of CWE's listings are surplus lab chemicals or unused hazardous material. The exchange, however, shares only information and is considered passive. CWE deals in hazardous waste and is run by one full time person. It produces a yearly newsletter and directory of industrial recyclers (Industrial Waste Exchanges, 1996, Ch. 2).

Some proactive exchanges provide community assistance by encouraging and teaching resource conservation. Others give on-site plant assessments of reuse and recycling potentials. One example of this is the *Industrial Materials Exchange Service (IMES)*, which has "Waste Exchange Activators" in Chicago and southern Illinois (A Review of Exchanges, 1999). Activators visit companies and offer waste reduction tips and background of the exchange's operation. They consistently find that companies are not aware of the valuable composition of their waste, nor the potential to reuse it.

The Iowa Department of Economic Development, which leads the administration of the Iowa Waste Exchange (IWE) is an extremely proactive consulting exchange. The waste exchange service is free for industrial users to encourage them to help reduce the state's waste production and cut landfill dumping. Normally, the Iowa Department of Economic Development targets high sources of waste production. Following this, the generators and the IWE are contacted and made aware of each other's activities. A complete inventory of the wastes being produced is compiled during a consultation between the two. The consultant then segregates wastes and assesses the opportunities for the company to reuse or recycle. If no possibilities can be seen, the information is added to a database so that future matches can be made between consumers and generators. Even though it is very proactive, the organization is fairly small, with between 10 and 20 employees at a time (Drenner, 17/12/99).

2.6 COSTS AND FUNDING

The costs of an exchange are the salaries of its staff, the rent for facilities and the advertising expenses. Budgets may vary greatly. An exchange can cost only US$10,000 to run with a single part time volunteer, but it may also require a budget of US$200,000 and need a number of full time employees, a large office, storeroom, publications, and active advertising.

Bilateral academic exchanges are usually initiated with little or no start-up money because the programs are run through university Health and Safety Departments. However, centralized exchanges, though, may require considerable money and staff time. Laura Grissom, manager of the Duke University Chemical Exchange, noted that efforts at the start of their program involved a week to remove outdated materials, import newer usable substances, take inventory and organize. Currently she reports that the chemical inventory is updated at least several times a week (Grissom, 10/12/99). M. Raja's bilateral exchange at the University of South Carolina, on the other hand, reported that only three to four hours a week are necessary to run the program (Raja, 16/12/99).

Portland State University Chemical Consortium's 72 members include colleges, schools, private agencies, and industries. With this large number of participants, greater manpower is required than in other academic settings. The manager, Larry Pardun, reports that up to six full time employees are necessary at one time.

Exchange budgets are funded privately, through the government, or by a combination of both. The majority of industrial exchanges in the U.S. are at least partially state or federally sponsored; they cannot rely solely on private funding.

States recognize that waste exchanges serve a market need, and will support them when necessary. The revenue from disposal fees is one method through which state governments fund exchanges. For instance, the *Iowa Waste Reduction Center (IWRC)* receives 10 cents per ton of waste sent to state landfills. *Industrial Materials Exchange (IMEX)* in Seattle uses part of an annual fund gathered from waste disposal surcharges in the area (Industrial Waste Exchanges, 1996, Ch. 5).

Private funding methods may include a variety of member fees consisting of annual subscription charges, advertisement expenses, listing fees or purchasing fees. Although these fees may deter exchange users, the additional source of income is necessary to pay for materials catalogs, which can cost up to US$5 per copy to produce. The *Southeast Waste Exchange (SEWE)* charges US$25 per year, while the *Pacific Materials Exchange (PME)* charges a much higher US$48 per year to their subscribers. It was discovered that, although subscription fees can balance basic costs, they can never be enough to make an exchange profitable (Industrial Waste Exchanges, 1996, Ch. 5).

Some exchanges charge listing fees of US$50 per 10 substances. With this charge, 400 listers can generate only US$20,000 per year, which is insufficient to cover operating costs. The *Northeast Industrial Waste Exchange (NIWE)* reports that its revenue fell by half after it began charging listing fees (Industrial Waste Exchanges, 1996, Ch. 5). Due to problems with these fees, most exchanges prefer to charge the donor when a successful transfer is made. This supplements funding, and shifts some of the cost from the taxpayer to the companies that actually benefit from the exchange. The Arizona Exchange, for example, uses this method so that only the users of the given material must pay for its acquisition.

Advertisement revenue is another possible source of meeting budget requirements. Like other funding options, this rarely gives surplus revenue. For example, the *Southeastern Waste Exchange (SEWE)* earns less than US$5,000 per year in advertising revenue from its bimonthly catalog (Industrial Waste Exchanges, 1996, Ch. 2).

2.7 *THAILAND'S ENVIRONMENTALISM AND ECONOMICS*

Currently there is no evidence of any material or chemical exchange program among Thailand's industries, or within its university system. A need for such a program at Chulalongkorn University was determined in a 1996 evaluation of chemical safety there (Eckman, 1996, 52). Industries in Thailand have also shown a need for an exchange. Economic and industrial growth over the past few decades has produced serious pollution problems. One of the major causes of this pollution is illegal chemical disposal. For example, the Nam Siew river is currently twice as salty as seawater because of improper mining waste disposal (So and Lee, 1998, 122). The following sections will discuss some of these problems, their causes and their social effects.

Material exchange is one of the options that could be pursued in Thailand to help alleviate some disposal problems. In order for the proposed system to be successful, it had to be suitable both culturally and economically. Of equal importance, the presentation of the proposal had to be attractive to Thailand's industries and universities.

2.7.1 RECENT ECONOMIC CHANGES IN THAILAND

During the past several decades, the Thai economy has boomed. Many upper-class Thais found themselves increasingly wealthy while, the middle class grew substantially. Most economic growth was due to expansion in tourism and manufacturing industries as well as an influx of foreign investments (So and Lee, 1998, 120). Several million tourists visited Thailand each year, spending about US$8 billion (LaBrecque, 1998, 67). This growth in Thailand remained unchecked for several decades, until recently.

On the second of July, 1997, the Thai economy plummeted. The Bank of Thailand stopped propping up the baht and within a couple of months, the exchange rate dropped 25% to 32 baht to the US dollar (Shari, 1997, 49). By 1998, the money had further devalued to almost 60 baht to the US dollar before it began to climb again. This plunge crippled Thailand's economy, causing finance companies to fall, stock prices to plummet, and public works projects to be abandoned. Foreign companies that were using Thailand as a new market also suffered, such as General Motors and some Japanese car manufacturers (Shari, 1997, 49).

Although there are signs of improvement in the economy, and Thailand is currently better off than some other Asia countries, Thais will continue to feel the hardship until the economy begins to grow again (Einhorn, 1998, 57).

2.7.2 ENVIRONMENTAL EFFECTS OF INDUSTRIAL EXPANSION

There are currently an estimated 300,000 factories in Thailand, many of which are involved in Thailand's petrochemical industry, transforming oil from nearby sources into plastics for use in Thailand and as exports. Some have speculated that this area will soon be the world's center for plastic production (Weininger, 1/12/99). Most of the industries in Thailand are based in the central region, near Bangkok (So and Lee, 1998, 122).

Poorly planned industrial growth in Thailand has taken its toll on the environment, which is now in very bad condition. As in America in the 1960s and 1970s, uncontrolled polluting and dumping have created conditions that are both unhealthy and costly. The Chao Phraya River, which runs through Bangkok, is biologically dead and unable to support many industries and people who previously depended on it. Worst of all is the air pollution produced by the thousands of factories and two million cars in Bangkok. In 1989, about 900,000 people, almost 20% of the population, suffered from respiratory illnesses (So and Lee, 1998, 121).

As these pollution problems have become more obvious in the everyday lives of Thai people, the awareness of environmental issues has increased significantly. These concerns gave rise to numerous student environmental organizations. In the past 25 years these groups have had varied success, from helping to overthrow the government to being dictated by it. Regardless of their inconsistent political success, they have greatly helped to shape the current attitudes concerning the environment in Thailand.

2.7.3 THAI ENVIRONMENTAL ATTITUDES

Before 1970, there were no environmental groups of any kind in Thailand. At this time, several student ecological clubs formed and were able to express the anger that students felt about the environmental policies of the military government. A similar movement had started in the US ten years earlier in the 1960s.

In 1973, the student groups were responsible for triggering a chain of events that culminated in the overthrow of the military government. This return to civilian rule lasted until 1976, when a coup restored the military and Prime Minister Thanin to power. He then targeted the students involved with the government overthrow, who, in response, fled to the forests of northern Thailand. Nonetheless, concern for the environment continued to grow because of unbridled development, a rapid expansion of the middle class, and more tolerance by the government toward dissent (Quigley, 1996). Worldwide environmental movements supported these developments in Thailand.

Eventually, the government was forced to respond to the concerns of the environmental groups. From 1982 to 1984 there were mass demonstrations that protested the construction of the Nam Choan Dam, which was subsequently shelved. In 1986 the dam was again proposed eliciting an even greater protest. The government, with fears of being overthrown, again shelved the project.

By the 1990s, there were about 200 Non-Governmental Organizations (NGOs) concerned with the environment in Thailand. These grassroots groups did not shy away from conflict and thus have had some success. Unfortunately, they are usually dependent on foreign financing. Many of them do not have long term staffs that are professionally trained. Their public relations are underdeveloped and closely scrutinized by the government.

One of the most successful NGOs is the Project for Ecological Recovery (PER). Established in 1985 with about 10 permanent staff and an annual budget of US$100,000, PER has been very visible and confrontational in challenging many environmentally damaging corporate projects (So and Lee, 1998, 128).

In the last 10 years, many companies in Thailand have adopted environmental principles and sponsored their own environmental business organizations. These organizations respond to confrontational campaigns against large corporations by grass roots movements. Companies began to change their habits in an attempt to appeal to the new, more environmentally aware middle-class consumers.

Most environmental business organizations are set up by executives or their relatives. These organizations usually get more results than the grass root approaches because they are better funded, have more resources, and are more skilled at working with the media. The budget of the largest business environmental organization is four times the size of that of the largest NGO (So and Lee, 1998). This enlarged budget can be attributed to business' strong government ties.

It is necessary to outline the relationship between Thai business and government because it differs greatly from the equivalent relationships in America. Thai society in general is set up as a hierarchy, in which rank is based on age and status. The people involved in the upper ranks of the governmental hierarchy are usually the same as those in top positions in business. It is not uncommon for a former CEO to become Prime Minister, and the business community's power seems to survive the military coups (Zeugner, 2/12/99).

Perhaps it is because of this connection that business organizations prefer cooperation with government officials to confrontation. This tactic gets better results, but leads to avoidance of some touchy subjects, such as deforestation, logging and dam projects.

The demonstrations in the 1970s, the establishment of the NGO's in the 1980s and the business environmental organizations in the 1990s, all created pressure on the Thai government to enact environmental protection legislation. There are currently several major governmental organizations that are concerned with such issues including the Ministry of Public Health, the Ministry of

Industry, the Ministry of Agriculture, and the Ministry of Science, Technology, and the Environment.

The initial thrust of this government involvement came when the Ministry of Science, Technology, and Energy (MOSTE) was established on March 24, 1979. Its purpose was to promote scientific research and convert the results to applicable working technology. In 1992 the role of this ministry was expanded to include protection and management of the environment, resulting in a change in its name to the Ministry of Science, Technology, and the Environment. This conversion was partially prompted by an accident at the Port Authority in Bangkok where foreign and domestic sources had been placing chemicals in unregulated storage for decades. In 1990 this waste exploded, demonstrating the consequences of the lack of regulation (Zeugner, 18/11/99).

MOSTE is responsible for developing policy and an action plan to promote socio-economic growth and development, while managing rehabilitation and efficient use of Thailand's environment and resources. It has 13 agencies working toward these goals.

These agencies have promulgated regulations and legislation concerning everything from air quality standards to labeling for toxic substance manufacturing (OSTC, 1999). Similar to US EPA laws, the Thai regulations can get as specific as defining the height and coloring of lettering for "EXPLOSIVE. NO SMOKING" signs and so on. Unfortunately, the long list of regulations set up by such government organizations concerning pollution is ineffective without proper monitoring of the actual disposal practices.

Through the same act that modified MOSTE, the government set up a fund to support projects concerned with environmental concerns. This fund has been underused due to the complicated procedures involved with attaining approval for the money (So and Lee, 1998, 137).

The material in this chapter provided information about materials exchanges in the United States and conditions in Thailand. These findings were used to achieve the goal of this project. The following chapters describe how this was done.

CHAPTER 3: METHODOLOGY

The creation of a chemical exchange could only be completed after appropriate research was conducted. Chapter 3 outlines this research, which encompasses practices, attitudes, and facilities at Chulalongkorn University (CU). It restates the main goal and then discusses research objectives. The bulk of the chapter describes methods used for this research both in the United States and Thailand. It finishes with a description of how the Chemical Exchange at Chulalongkorn University (SCECU) was created.

3.1 *PROJECT STATEMENT*

The purpose of the *Surplus Chemical Exchange at Chulalongkorn University* (SCECU) IQP was to implement a viable chemical exchange system for use internally at Chulalongkorn University (CU), which could be expanded to other universities, government laboratories, and commercial sectors of Thailand.

3.2 *TOPICS EXAMINED*

This section describes the individual subjects that were researched for this project. The first topic, section 3.2.1 , encompasses chemical waste management and disposal practices in US universities and industries. Since the US has more material exchanges than any other country, it served as a good source of possible solutions to CU's chemical disposal problems. The results of this study were discussed in Chapter 2. Section 3.2.2 describes how information about a suitable organizational structure for SCECU was gathered. Finally, section 3.2.3 describes the steps taken to evaluate the success of an exchange at CU.

3.2.1 THE US SYSTEM OF CHEMICAL HANDLING AND EXCHANGE

To understand the success of academic and industrial chemical exchanges in the US, essential studies were conducted regarding operating procedures, motivating factors, and government regulations.

Before the operation or the motivations behind chemical exchanges could be understood, the policies and regulations that affect them had to be known. An analysis of the rules created by the EPA for proper practices in storage, handling, and disposal was therefore conducted.

Investigations of materials exchanges in the United States were undertaken, including information pertaining to funding, staffing, transportation, and storage needs of exchanges. In addition, successful promotional efforts were also examined.

3.2.2 ORGANIZATION OF AN EXCHANGE AT CU

The background information gathered in the US demonstrated that there are several different schemes that can be used to organize an exchange. The differences between these methods are based on the objectives and capabilities of the exchange's staff. In Thailand, similar factors could determine the way an exchange is organized. The knowledge of programs in the US was applied in formulating questions about operational facilities and electronic capabilities. These questions were asked of Professors, students, government officials, and industry representatives. Questions about confidentiality, advertisement, and funding were asked. The responses to these inquiries were pertinent to organizational decisions, such as whether to recommend a central or bilateral exchange system.

3.2.3 EVALUATION METHODS FOR AN EXCHANGE IN THAILAND

To determine the potential for the success of SCECU, Thai government regulation, environmental motivation of possible participants, and waste management practices at CU, were examined. More than 20 professors and students at CU were interviewed for this study. In addition, disposal techniques were evaluated to discover current awareness and attitudes of CU staff and students toward pollution from laboratory chemicals.

Like the US, Thailand has laws regulating the storage and disposal of chemicals. It was necessary look into these regulations and evaluate the extent of their enforcement. Thai government officials and industry representatives were valuable resources for describing the awareness of these regulations and the level of their enforcement in Thailand. NGO's were not contacted because the information revealed by studies in the US and from other sources in Thailand was adequate to make conclusions about Thai environmental attitudes.

3.3 *RESEARCH METHODS*

The following sections discuss the various techniques used in the United States and in Thailand to obtain the information outlined in the previous section.

3.3.1 INTERNET SEARCHES

While in the United States, the project group spent a great deal of time searching the Internet for information about chemical exchanges in the United States. Preliminary investigations revealed that there is virtually no information available in print concerning exchanges, which confined searches to the World Wide Web.

Contact details such as phone numbers and email addresses were obtained from the web pages of the exchanges themselves. These homepages were generally found via links from other web pages such as those of university chemistry departments. Six universities were contacted for information about their chemical exchanges: the University of Massachusetts at Amherst, the University of South Carolina, Portland State University, the University of Toronto in Canada, Cleveland State University, and the University of Berkeley at California. Archives containing governmental rules and regulations were searched on the official pages of the EPA.

3.3.2 PRINTED LITERATURE

Background material concerning Thailand was partially obtained from printed literature. Several books gave an overview of Thai society and its religious institutions, while magazine and journal articles summarized recent economic activity and environmental attitudes. Lectures on Thai history, religion, and language at Worcester Polytechnic Institute conducted by Professor John Zeugner and Ms. Sumalee Passaretti supplemented these secondary sources.

3.3.3 UNDERGRADUATE SURVEYS

Undergraduate students in the Chemistry Faculty at CU were given a survey that evaluated their environmental awareness and safety practices. The intention of this survey was to determine the extent of the safety training that the students have received, how well they adhere to this training and their awareness of the environmental consequences of their chemical waste disposal practices. A survey was conducted with undergraduates in order to generate reliable answers from a larger number of students. The project team found that Thai undergraduates tend to read and write English better than they can speak it, thus justifying the use of surveys instead of interviews for undergraduates. The survey, responded to by 60 students, as well as more information on surveying methods can be seen in Appendix F.

3.3.4 INTERVIEWS

Most of the knowledge gathered in Thailand came through interviews. The information sought was based mostly on personal opinions or experience, making an interview the perfect form of inquiry. Before these meetings were carried out, good interview techniques and practices were examined. This was done through a brief literature review of interviewing techniques.

There are three types of interviews used for this project: standardized, semi-standardized and non-standardized. A complete description of these can be seen in Appendix G. A completely non-standardized interview technique was used while interviewing government officials, as well as other organizations outside of the university. Professors received semi-standardized interviews and graduate students were given both semi-standardized and standardized types.

Person-to-person, telephone, and email interviews were conducted with materials exchange operators and university safety staff in the US. Most of these interviewees in the US were located far away from the WPI campus, so telephone conversations were more common than personal interviews. In Thailand however, interviews were all conducted in person. Audio devices were not used to record any of the interviews; instead notes were taken by the project team and transcribed afterwards. A complete list of the interviewees and the interview notes can be seen in Appendix G.

3.3.5 ATTEND CONFERENCE

The *International Conference on Industrial Hazardous Waste Management* was attended by the project group and advisors in Bangkok, Thailand on 28 January 2000. This conference was organized by the Environmental Research Institute at Chulalongkorn University (ERIC) and the New Energy and Industrial Technology Development Organization (NEDO) from Japan. A paper was written for the conference proceedings entitled, "Exchange Programs for Chemicals and other Hazardous Wastes in North America," using the results of the research conducted in the United States (see Appendix I). The presentations by others during the conference provided information about current practices in Thailand and the government's future plans. Some relevant knowledge was also gained from informal discussions about waste management in Thailand with members of government and industry.

CHAPTER 4: RESULTS

The following chapter records information obtained by the project group while in Thailand. This information concerns the two main questions discussed in the previous chapter: how to design an exchange for CU, and it can be successful. These questions were answered from the motivations of students and professors at CU, and the potential capabilities of the exchange. Since the results that address these two research topics interlace and overlap, this chapter is organized by the information collected.

Section 4.1 builds a comprehensive view of chemical practices at Chulalongkorn University (CU), the focus of the report. It includes the results of numerous interviews concerning regulations and chemical practices on the CU campus, as well as student and teacher attitudes toward their disposal practices and their environmental awareness. Following this is an overview of Chulalongkorn University's computer resources, including Internet and network capabilities and electronic inventory systems that are being developed.

Next is an evaluation of the current and future chemical practices at KMUTT, which is modeling several initiatives in chemical waste management.

The chapter concludes with an evaluation of Thai regulations and industrial practices and shows the government's intentions for industry, the actual methods employed, and the methods to be implemented in the future.

4.1 INFORMATION GATHERED CONCERNING CHULALONGKORN UNIVERSITY

The primary research goal in Thailand was to acquire knowledge regarding Chulalongkorn University, the setting of our exchange program. Background studies included an overview of CU's history, as well as general demographic features within chemical consuming departments. Information regarding CU's current and future chemical practices pertaining to inventory, waste disposal, and safety are included in the following section. At the conclusion, an evaluation of CU computer resources was conducted in order to examine possible operational utilities for the exchange

4.1.1 ADMINISTRATIVE STRUCTURE AND CHEMICAL USE AT CHULALONGKORN UNIVERSITY

The administrative structure of the university is comparable to that of the US government. There is a president who is elected every two years, who may be re-elected numerous times. Dr. Supawan observed that if a president tries to change too many things within his term, he will not be re-elected. A requirement for the president, the executive board, and the senate is that all members must have been employed by CU for a specified number of years in order to be elected to these positions. The senate's function is to make suggestions to the president who must then pass them on to the Ministry of Education for approval. The senate is comprised of between 2 and 4 faculty members from each CU department.

The body itself is a dynamic group with a rapidly changing membership. CUs relatively de-centralized decision-making process can often times make reforms difficult to achieve. Many changes are, in fact, more under the control of the Department Heads and less in the hands of the Dean.

Areas of study have multiplied rapidly growing from 4 to18 faculties in a little over 80 years. Numbers have grown accordingly among staff and students as well. Presently, there are 8 faculties, including medical sciences, in which students' majors have a chemical component. However, only two faculties and one college within CU utilize laboratory chemicals. Within the Faculties of Science and Engineering and the Petroleum and Petrochemical College of CU, there are at least twelve departments that could potentially handle these substances. The Faculty of Science contains six of these departments: Biology, Biochemistry, Chemistry, Chemical Technology, Materials Science and Molecular Biology. The Faculty of Engineering includes chemistry in the departments of Chemical Engineering, Environmental Engineering, Mining and Petroleum Engineering and Water Resource Engineering. The Petroleum and Petrochemical College has two departments that use laboratory chemicals. The number of undergraduate students within these twelve majors totals over 6,000. Graduate students in the masters programs amount to approximately 2,000. The staff needed for such a large student population ranges in numbers from 15 to 35 per department (CU web page, 2000).

4.1.2 SAFETY AND DISPOSAL GUIDELINES IN LABORATORIES

Most professors' safety guidelines require students to wear lab coats, safety goggles, gloves and close toed shoes. Dr. Lursuang of the Chemical Technology department requires that before each lab, students find the MSDS for all substances involved. The sheets must be handed in for a student to be admitted into the laboratory. Compared to these requirements, procedures in other labs are less demanding. General attitudes can be summed up by Dr. Varipun's statement, "It's one thing to tell someone to do something, getting it done is a different story" (Varipun, 21/1/00).

With respect to disposal, some professors require only that chemicals not be poured down the drain in their laboratory. Instead, the chemicals are to be separated and put into containers for solvents, organics and heavy metals.

4.1.3 CURRENT CHEMICAL PRACTICES AT CU

It was found that CU chemistry practices that operations vary greatly among different departments and even in different classes within a department. Professors and graduate students were interviewed and undergraduate students were surveyed to gain a detailed picture of chemical stocking, safety, and disposal practices. These interviews revealed that while there is inconsistency in the practices, all of them could be improved.

4.1.3.1 CHEMICAL INVENTORY

Chemical stockroom management at Chulalongkorn University differs greatly from that in universities of the US. The CU inventory and ordering system shows little uniformity. As mentioned, each faculty in which chemicals are used, has several different departments. It was found that most of these departments also have chemical storeroom dealing solely deal with chemicals ordered for their undergraduate teaching laboratories. The quantity of stock varies widely among departments. Dr. Thirayut, a professor in the Chemistry

Department who has taken charge of its stockroom, reported that the department storeroom contains nearly 2,000 chemicals and requires a full time manager. The Chemistry storeroom accepts second-class chemicals, which are any partially used chemicals still in their original containers. Dr. Lursuang of Chemical Technology reports that his department only requires one closet and part of a professor's time to manage its 100 chemicals. However, this department does not accept second-class chemicals.

Generally speaking, there is no way for storerooms managers to know the contents of any of the laboratories in their department, or to know of chemicals in other departments. This could be a cause for the lack of sharing of materials between individual staff and between departments. Dr. Lursuang reports that no one has asked for chemicals from his labs before, but he feels that small amounts of materials from all departments should be free to use. People within the engineering fields do report some chemical swapping. The lack of overall organization also affect researchers who have to share laboratories. They may spend more money than was budgeted for chemicals because the amounts, owners, and locations of substances left on a shelf elsewhere may be uncertain or unknown.

4.1.3.2 CHEMICAL ACQUISITION

The ordering of chemicals is handled similarly throughout all departments and is handled differently for teaching laboratories and research laboratories. In order to minimize the volume of purchased chemicals, the staff assign the same experiments within teaching laboratories every year. Chemical orders are collected from the staff and processed by the department storeroom manager. For departments without a storeroom manager, the person who is in charge of its stock handles this task. Through this process, orders within the department are combined and bulk requests are formed, which generate discounts and easing the acquisition process (Amorn, 19/1/00). This keeps budgets low and minimizes waste.

Researchers follow an entirely different procedure. Fourth year Chula undergraduates and graduate students are allotted a grant for their research projects by the university, which typically equal 5000 baht for undergraduates and 10,000 baht for graduate research. Research students will typically decide on the chemicals they need, fill out a purchase order, and obtain a signature from their advisor. The chemicals are then sent directly to the lab (Supawan, 26/1/00).

Chemicals themselves are typically ordered from Merck or through Fluka in Japan or Switzerland because there are no closer distributors. Ordering can prove to be a very time consuming and costly process. It is common for researchers to report that weeks will pass before their order is delivered, Dr. Varipun, for instance found that some specialized chemicals require six weeks for delivery. Because of this delay, students and teachers will often order larger volumes of a substance than they need simply because it is cheaper and more time efficient to do so (Thirayut, 17/1/00). The fact that there are no regulations or costs associated with chemical disposal, allowing students and staff to discard as much as they choose, also makes this method a "good" choice.

4.1.3.3 DISPOSAL

The majority of students interviewed were not aware of the fate of their waste materials after disposal. Teachers reported that solvents, on occasion, are recycled and reused. Many undergraduate students are instructed by their teachers to fill a container with all products and wastes from the entire class. Some others instructors require these wastes to be separated into three separate containers: heavy metals, organics and solvents. It is not clear what happens to these containers, some are placed on a shelf in the lab or a storeroom in their department. Others are combined with compatible materials and packed with sand in a steel drum, which is then placed in the accumulating pile, seen in *Figure 4-1* (Supawan, 11/1/00).

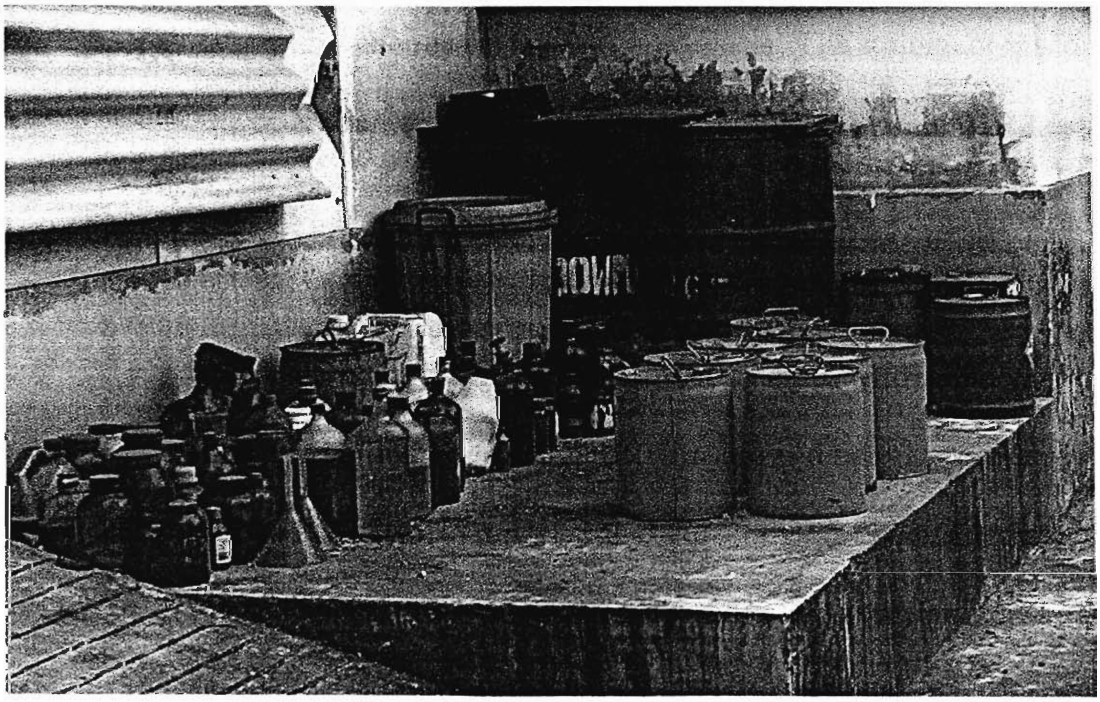

Figure 4-1: Chemical waste behind Chemistry Building 1.

One graduate student reported seeing the collectors come to take the separated waste containers from the lab. The collectors allegedly combined the three separated containers into one and removed it, presumably to the pile in the rear of Chemistry 1. This pile has continued to grow for several years and there are no immediate plans to dispose of it.

In general, wastes that are carefully separated are more likely to stay in bottles, or to be packed in drums, however, it is likely that at least a portion will see the drain. Some students reported that they were instructed to dilute chemicals with water and dispose of them in the sink.

Dr. Amorn stated that there are no treatment facilities connected with the drainage system of any building at CU. However, he also noted that Bangkok has a new municipal waste treatment facility that is supposed to treat harmful chemicals in the water system. This claim was refuted by Khun Varapinit from GENCO, who reported that the Bangkok facility does not deal with most laboratory chemicals, only organic waste. His statement is more consistent with the operation of standard American municipal waste facilities.

4.1.3.4 SAFETY

Adherence to safety guidelines at Chulalongkorn University is similar to the observance disposal procedures. The professors and graduate students agree that current methods are usually unsafe and better procedures need to be obeyed. They also reported that currently lab coats, goggles, fume hoods and closed shoes are not always employed when appropriate. Some of the equipment used, such as the Bunsen burners, is also reported to be very old and dangerous. Graduate students and professors reported a number of small accidents related to chemical use. Though none of these were severe, ranging from allergic reactions to chemical and thermal burns, the potential for a more serious accident is present.

4.1.4 INVESTIGATION OF ATTITUDES AT CU

Thai Culture is inherently non-confrontational. In addition to direct observation by the project team this attribute was also pointed out in several interviews. Dr. Supawan noted this in a discussion of university politics and Dr. Yaron Yoel mentioned during a discussion of waste management and pollution that Thais hate to point fingers at responsible parties.

4.1.4.1 ATTITUDES TOWARD SAFETY

This was more than apparent in our interview results, when only three out of eight interviewees responded in the negative when asked if handling practices at CU were safe. However, all of the respondents went on to give instances of students' unsafe behavior. In addition, when asked if students were at risk of injury, all said yes. The use of lab coats and goggles varied within departments, apparently depending on the instructor. Everyone agreed that the graduate students' habits are much safer than those of undergraduates.

4.1.4.2 ATTITUDES TOWARD DISPOSAL

It was the unanimous opinion of interviewees that proper disposal of chemicals is important for the environment. However, interviewees once again told stories of individual students knowingly disposing of chemicals improperly. Interviews also revealed that students commonly pour chemicals down the drain even when they know they are not supposed to, because "it's easier." In addition, answers to question 10 on the Undergraduate Survey on Waste Management (see

Appendix F) indicated that they did not think chemical waste contributed to pollution in Thailand. This may show the lack of concern or awareness that students, and perhaps professors, have for this problem. Although they may have the view that chemical pollution is a problem, but not very significant when compared to air pollution in Bangkok.

Those in the Department of Chemical Engineering seemed more concerned about proper disposal than others because their building was designed as a large office building, not a lab, and its plumbing is more delicate. Seven out of eight professors and graduate students replied that they would be willing to change their disposal practices if it would be beneficial for the environment. However, interviewees were unsure about the participation of others. One out of three groups of graduate students that were interviewed agreed that people would not want to spend more time on an alternative disposal method, because time is money. They reinforced this comment with the explanation that some students currently pour chemicals in the drain now to save cleanup time.

4.1.4.3 ENVIRONMENTAL AWARENESS

The environmental attitudes of the Thai students and staff were also pertinent to this project and were thus studied in depth. Professors, graduate students and undergraduates were asked about their own and their associates' environmental awareness. Amongst graduates and professors, all reported that they were aware of environmental problems. Undergraduate responses were divided between moderately aware and very aware, and only 11% said that other students were more aware than they were. Two graduate students reported that most other students were unaware of environmental issues. Fourteen percent of the undergraduates surveyed rated others' environmental consciousness at only 2 out of a possible 5. This was the most negative response received to any question. All graduate students, save one environmental engineer, said that the professors are environmentally aware. In addition, the majority of undergraduates rated their professors as very knowledgeable, and only 20% thought their knowledge was superior to that of the professors. It was apparent

Table 4-1: Questions on Undergraduate Survey

Please Rate the following 1-5 (5 being highest)	
1	Your experience with laboratory chemicals
2	The amount of instruction you have received on the proper disposal of chemical waste
3	The instruction that you have had on laboratory safety
4	Your awareness of environmental problems in Thailand
5	The environmental awareness of other CU students
6	The environmental awareness of CU professors
7	The importance of proper chemical waste disposal
8	The importance of reducing chemical waste
9	Your willingness to change your laboratory practices to be more environmentally friendly
10	The contribution of chemical waste to pollution problems in Thailand

from interview responses that the graduate students are far more aware of environmental concerns than the undergraduates. Table 4-1 shows the questions that were asked of the students, the results are shown in *Figure 4-2*. The survey itself can be seen in *Appendix F*.

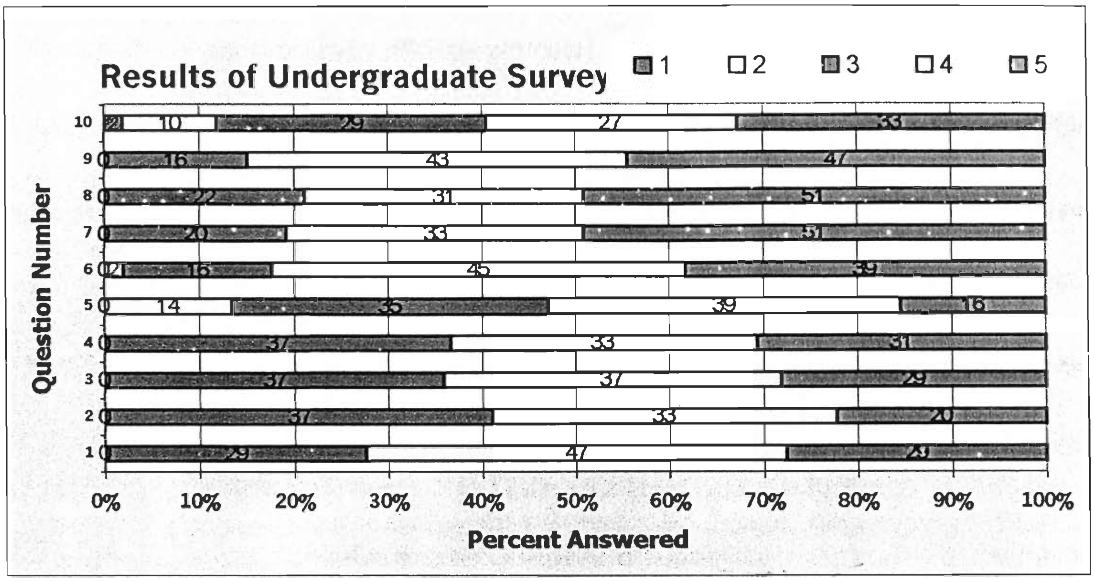

Figure 4-2: Results of Undergraduate Survey

4.1.4.4 ATTITUDES TOWARD A SURPLUS CHEMICAL EXCHANGE AT CU

Professors and students were also asked about their attitudes towards a surplus chemical exchange program at CU. Replies were unanimous, with all agreeing that CU would greatly benefit from such a program.. In fact, Dr. Lursuang of Chemical Technology supplied a handwritten list of 12 surplus chemicals on his department's shelves that the staff was willing to share with other departments. He believed that such a list could be easily updated on a regular basis. The Chemical Engineering Analytical Laboratory gave a printed list of chemicals they were no longer using, taken from an inventory spreadsheet. The Biochemical Engineering laboratory had a similar list with several hundred possible donations. Dr. Supawan stated that it would be possible to create a list for the Chemistry Department as well.

In most cases a desire for owner confidentiality in the exchange was not found to be an issue. All of the professors said that the identity of the chemicals they use is not a secret. Dr. Supawan pointed out that the volume and intensity of the research in Thailand doesn't rival that of the US, and Thai researchers are not as competitive as Americans. In addition, Prof. Piyasan noted that it would not be difficult to get a list of chemicals being used in a lab from a staff member or graduate student, making a security feature in the exchange irrelevant.

4.1.5 FUTURE ACTIVITIES IN CHEMISTRY AT CU

There are activities and plans on campus to further substantiate attitudes of environmental awareness and a need for a waste management on campus. There is a new Science Center (see *Figure 4-3*) currently under construction. It is a 21 story building containing approximately 1800 m^2 of usable space per floor. Nine of these floors (floors 7-15) will be occupied by the chemistry department and its 2,000 undergraduate students. Human health and environmental considerations were taken into account when the building was designed.

Figure 4-3: New Science Center

For example, efforts were made to safely ventilate the 275 laboratory fume hoods by having two separate systems, one especially for the organic chemistry labs, the other for all inorganic laboratories. Steps were also taken to manage waste water streams exiting the building. There will be two water treatment systems, one for sewage and gray water, and the other for chemical treatment. Laboratories will also use electric heaters instead of Bunsen burners to alleviate the need to distribute gas throughout the building.

In addition to these physical changes, several professors noted that they would like to use the move into the building as an opportunity to change the safety and disposal practices in their classrooms. A better method of disposal has not been proposed but Dr Amorn reported that a method will be decided upon when the chemistry department moves into the new Science Center. Both he and Dr. Supawan suggested that the Chemistry Building 2 become a safety training center. Additionally, they would like to see the Chemistry Building 1, which presently contains the stockroom for the chemistry department, be changed into a university wide chemical stockroom managed by the Chemistry Department.

The management of such a stockroom and other future inventory functions will rely heavily on computers.

4.1.6 CU COMPUTER RESOURCES AT CHULALONGKORN UNIVERSITY

An Internet based system was the chosen as the most suitable format for the chemical exchange inventory system. This choice was feasible because of the abundance of computers, technical capabilities of the current network system, and the computer knowledge of the staff at CU.

The following section discusses this choice and evaluates the software systems currently in use that could be usable for the chemical exchange.

4.1.6.1 TECHNICAL CAPABILITIES

Computers were found in abundance on the CU campus. In addition to the departmental computer labs, oftentimes professors had computers available within their laboratories. Most PCs observed were running Microsoft Windows and had Internet access using Internet Explorer, Netscape Navigator or another Internet server. In addition, all computers could link to the campus network so that one might access their department server from anywhere on campus. Dr. Amorn mentioned, however, that because of bad wiring the Chemistry Department's server is often "down." Although this aspect of the system was not studied in other departments, CU's network reliability was brought into question.

As on most university campuses there is ample technical knowledge at CU for instructors to utilize basic computer functions. The general consensus among interviewees was that all the staff at CU are at least capable of using MS Office, accessing the campus network, checking e-mail and using the Internet. The knowledge and availability of computers has led to the development of software for the specific use of the chemical users.

4.1.6.2 CHEMTRACK INVENTORY SOFTWARE

The existing chemical inventory systems at CU were studied to determine if one could be adapted to incorporate the chemical exchange. Dr. Thirayut provided the project group with a demonstration of ChemTrack.

The ChemTrack software package was developed by Dr. Varipan and two Management Information Systems students as part of the Environment, Health, and Waste Management (EHWM) program of the Industry/University Cooperative Research Center (IUCRC). CU began a pilot study of this computer program in order to monitor chemical costs in ten departments. The intention was to have all departments that use chemicals to utilize ChemTrack in their stockrooms in the future. However, some departments, such as Chemical Engineering, have chosen not to manage their inventories with ChemTrack, and some have never even heard of it. Still in its first year of operation, ChemTrack stores information about 7,000 chemicals in its database and is set up in seven different departments at CU, as well as at two other universities. The long term goal of the program is to link all ChemTrack inventories while keeping each department database separate.

Currently, Dr. Thirayut is testing and evaluating the functions of ChemTrack. He has been using the system to backlog chemicals that have been collecting in his department for 30 years, and at the same keep an up to date list of the 2,000 chemicals in his stockroom. His intention is to have all information entered on stock cards as well as in the electronic database, in case the system crashes. Handwritten stock cards also allow the stockroom managers to record chemicals in the database at a later time if need be. Currently, stockroom managers are the only people able to update the system. In the Chemistry Department stockroom, stock card entries are usually added to the system twice a week (Thirayut, 17/1/00). The same system is also being used in the Chemical Technology department (Lursuang, 25/1/00). In both departments, only new chemicals that enter the storeroom are logged in the ChemTrack inventory. When a professor retrieves a chemical, a form is filled to update the ChemTrack inventory. Following this, no further tracking of the material is done.

The backend of ChemTrack is an MS Access application programmed by Dr. Varipun and her associates. The database originally contained only a few fields, but has since been expanded to 10 fields. These include CAS#, Chemical Name (generally IUPAC), Compound Grade, Supplier Name, Catalog#, and the amount in the stockroom. There is a function within the program that can link a user to MSDS information for most chemicals. The database stores information about flammability, toxicity, corrosivity, and other important safety information. A useful field, which has not been added yet, will track the expiration date of a substance.

Through the ChemTrack web page (http://161.200.32.13/chemtrack) one department may view the inventory of others. CU staff find this function useful. They can share small amounts of fine chemicals without having to purchase new ones. To date, this sharing has never been done within the Chemistry or Chemical Technology departments.

The web page itself has a list of all participating departments and a space to search for the name of the substance required. Any number of departments may be searched simultaneously and the search results will return chemical name, quantity, and location. Dr. Lursuang finds the ChemTrack web page to be tremendously beneficial, but also tedious to search on. It necessitates that the searcher have a chemical catalog such as Fluka or Merck on hand to reference the exact chemical desired.

4.1.6.3 ORACLE INVENTORY APPLICATION

Recently a individual in the Faculty of Accounting worked together with a US company named Oracle to build a software package for inventory, budgeting, financing, and accounting at CU. The software was paid for by contributions from various faculties and cost the university US$500,000 to design and purchase. Currently it is being installed on campus. This application tracks expenditures and can determines an accurate cost for students to attend to CU.

Staff from all departments will be able to order supplies through this program by filling out a form. The software is designed to check a user's university account balance to ensure that there are sufficient funds. Following this, the program checks the campus inventory to see if the material is currently in stock. If so, the user is charged; if not, the program will send out the order. When the shipment arrives, the item is entered into the campus' inventory, the purchaser is notified and his account is debited. Dr. Amorn foresees that this software will become the standard inventory control in all faculties after its setup is completed in March. It may replace ChemTrack entirely, but Dr. Varipun believes that her application could be integrated into the larger Oracle database application.

4.2 PRACTICES AT OTHER UNIVERSITIES

Approximately five years ago the Industry/University Cooperative Research Center for Environmental and Hazardous Waste Management (IUCRC-EHWM) was implemented in Bangkok. The group involved representatives from the industrial sector as well as personnel from several universities. Their purpose was to develop a model for better chemical management, and two years ago the group was provided with the funding to so. Four models were designed, and the responsibilities distributed among 5 universities, one of which was CU. The current progress and future plans of a second IUCRC member university was evaluated in comparison to CU and is described below.

4.2.1 CURRENT CHEMICAL PRACTICES AT KMUTT

An investigation of King Mongkut's University of Technology in Thonburi (KMUTT) was conducted regarding their current chemical safety, handling and disposal procedures. Inspection of their efforts at waste minimization and management revealed that the university is very active. Efforts made in the past few years have resulted in a plan that includes future safety and disposal regulations and a recently completed functioning inventory database.

Inventory control has been gradually improving over the past few years. As in CU, the same chemicals are used every year for teaching laboratories, thereby reducing the number of chemicals in stock. Furthermore, KMUTT has been making attempts to substitute less harmful materials for the chemicals currently used. As mentioned, a database is now in existence that lists the name and location of all the chemicals at KMUTT. Another program is presently being designed which requires that all laboratory purchases go through a centralized stock system in order to minimize duplication in the stockroom.

Several years ago chemistry laboratories began *micro-scaling* techniques, in which the volume of substances used in an experiment is reduced. The practice has gradually spread across the entirety of the KMUTT campus. Because of this technique, in addition to *substitution*, a process in which substances are replaced with less hazardous chemicals that are compatible, waste streams have been cut by 75% over the past two years.

In addition to KMUTT's efforts in chemical waste minimization, waste management has improved. Approximately one year ago, a paper was written by Khun Jarurat of the Environmental Engineering Department regarding waste disposal and treatment on the KMUTT campus. "Many professors were eager to improve waste management but none were sure how" (Jarurat, 9/3/00). Now, every student and professor is responsible for the separation of reactants and products. Compatible chemicals are combined within glass bottles and stored within the laboratory when they cannot be recycled. Professor Wasanon reported that at the present, only small amounts of non-hazardous substances are flushed down the drain.

When Prof Wasanon, an organic chemist, was asked about chemical safety regulation at KMUTT, she stated, "We can only give advice, we cannot make students do anything they don't want to do". Therefore, it is requested that students wear appropriate attire, e.g., lab coats, safety goggles, and safety gloves. Observation of numerous KMUTT students showed that these safety requests are commonly accepted and practiced. Professor Wasanon also reported that she has never known of any accidents involving chemicals within any of the five departments dealing with hazardous substances.

4.2.2 FUTURE PLANS FOR KMUTT

As mentioned before, KMUTT has taken a leading role in promoting chemical safety and management. There are plans now underway to employ a Health and Safety Manager for the campus. The new position will be responsible for regulating all chemical management procedures, as well as developing better methods of waste disposal and treatment. Additionally, the Health and Safety Manager will be in charge of the implementation of a chemical safety training course which will be mandatory for all KMUTT staff and students.

Through cooperation among the government, the private sector and the university itself KMUTT is also building a new campus. The future plans include an industrial park in addition to academic buildings. The campus will include a waste collection and storage facility, a waste treatment plant, and a landfill for the storage of radioactive waste. Once built, all of these facilities will be available for use by other universities, industry and others.

4.3 *GOVERNMENT AND COMMERCIAL PRACTICES*

This section outlines current government efforts toward improving national chemical management practices. An overview of one chemical company's commercial processes and waste management techniques is provided. Then there is a brief description of procedures used for industrial hazardous waste disposal. The final subsection involves future plans for industrial waste disposal including the commercial need for chemical exchange.

4.3.1 GOVERNMENTAL REGULATIONS

Frequent chemically related disasters have been occurring in Thailand over the past fifteen years such as fires occurring at the Klong Toey Port in 1989, 1991, and 1993 (Master Plan, 1997, 104). Due to theses accidents, the government of Thailand recently made major efforts in chemical waste control. In order to protect the environment and people from the adverse affects of poor chemical management, nine ministries took on the responsibility of making guidelines, rules and regulations (Pornpis, 26/1/00):

The Ministry of Science, Technology and the Environment

The Ministry of Public Health

The Ministry of Agriculture & Cooperatives

The Ministry of Labor and Social Welfare

The Ministry of Commerce

The Ministry of Industry

The Ministry of Interior

The Ministry of Finance

The Ministry of Transport & Communication

Several committees were formed within these ministries and they combined with professional organizations to deal with waste problems. These professional organizations consist of concerned members of university staff, industrial associations, and environmental and consumer groups. The union of the government and these counterparts resulted in a group known as the National Coordinating Working Group (NCWG). NCWG's purpose is to develop documents that deal with the pollution and health problems in Thailand created by chemical waste. These include the *National Chemicals Management Profile* (NCMP) and *Thailand's First National Master Plan on Chemical Safety.*

The goal of these two documents was to catalog all existing chemical management methods in Thailand in order to strengthen handling, and disposal practices in the future. It was anticipated that the creation of these documents would help to coordinate the responsibilities of the ministries, as well as to improve the communication among all concerned parties. Additional expected benefits were the following (NCMP, 1998, 6):

- Providing knowledge and understanding of potential problems, in the environment and in human health, caused by chemical waste to workers and the general public;

- Improving awareness of chemical risks and develop a national safety culture;
- Strengthening national decision making and capabilities related to the management of chemicals;
- Providing information to chemical producers and traders;

Also discussed within the Master Plan and the NCMP are the major obstacles to the implementation of chemically safe practices in Thailand. Most problems arise from the absence of communication among the parties involved, the inefficiency of legislative enforcement, and the lack of awareness of chemical's the effects on human health and the environment. The combination of these problems makes implementation a daunting task.

Initial studies for the projects investigated chemical waste production. These studies classified chemical waste as industrial hazardous waste, commercial and service waste, medical and laboratory waste, port and shipping waste, community waste or agricultural waste (NCMP, 1998, 8). The problems arising from each category of waste and the steps needed to alleviate them were studied.

Currently, there are only two acts that regulate the production, import, export, possession, disposal and use of hazardous substances in Thailand. One is the Hazardous Substance Act of 1992 (B.E. 2535) issued by the Ministry of Public Health, the Ministry of Industry, and MOSTE. The second is the Factory Act of 1992 (B.E. 2535) issued by the Ministry of Industry (NCMP, 1998, 9). The

Hazardous Substance Act and an unofficial translation of the Factory Act can be found in *Appendix K.*

By the mid 90's numerous articles had been published outlining proper chemical handling, storage and disposal, but none of these were officially documented. In 1998 the Pollution Control Department under MOSTE brought in GAI Consultants from the US to create a *Feasibility Study on the Collection and Disposal System for Hazardous Waste Generated from Communities.* This study provided a base for the Community Generated Hazardous Waste (CGHW) program, including chemical management plans, as well as collection, labeling, storage, and transport requirements. Surprisingly, this study takes into account the large quantity of chemical wastes produced in Thailand's universities and recommends the regulation of them as well.

GAI's plan has prepared for the implementation of a nationwide program in four phases. Two phases address items such as administrative planning and systems implementation at a national level. The others focus on managerial training and initiation of program projects on regional and local levels. The program itself will be comprised of eleven steps to be completed in a five year period (CGHW, 1998, 59):

- Taking legal and regulatory measures
- Making plans for implementation of the CGHW program in local and regional provinces
- Establishing waste separation and storage program for each generator

- Developing a centralized collection and treatment facility and beginning the transportation of wastes to the facility
- Designing and constructing a radio-active waste landfill
- Developing a waste minimization program
- Beginning a recycle/reuse/return program
- Developing a plan for monitoring the effectiveness of the system
- Training staff
- Developing database and manifestation system
- Establishing a promotion and education program

Within the feasibility study there are several tables describing the state of Thailand's waste production and management in industry, laboratories, etc. Additionally there are tables that outline the quantity being re-used. GAI's document also includes a study of university-generated wastes and addresses laboratory chemicals and medical wastes. These tables can be viewed in *Appendix J*.

4.3.2 CURRENT COMMERCIAL PRACTICES

It was found that many current commercial practices differ greatly from that of academic institutions. This is mainly due to the large number of regulations that international corporations must deal with. Below is a description of one such industry and its products. Additionally, the services that are available to dispose of generated wastes are outlined.

4.3.2.1 INDUSTRIAL WASTE GENERATION

Of the 2.2 million tons of hazardous wastes produced in Thailand per year, 1.27 million tons are produced by industry. Within Thailand's 22 industrial estates, 74,000 companies are government registered, while over 200,000 are not. Unregistered industries contribute unknown amounts of hazardous waste to Thailand's environment (Yoel, 28/1/00). An employee of one registered corporation was interviewed to evaluate industrial practices and to see an example of how much waste passes through an industrial research laboratory.

HMC is a polypropylene manufacturer located in Mataput, Rayong. Initially HMC was created as a domestic company but was purchased by Montell Corporation and now sells polypropylene to 40 different countries. HMC currently uses propylene to synthesize approximately 360 metric tons of polypropylene per year. The propylene is a product made by three different methods by three companies in Mataput.

Generally speaking, the majority of research done at HMC is for applications. This includes seeking out future customers and products that they might need. When a suitable product is found, a technology team is given the task of creating it. Part of making a new product involves formulating a testing process to confirm the additives within the manufactured goods. To choose the chemical best suited for this testing process researchers make educated guesses and confirm them with trial and error. Usually HMC scientists only require two or three attempts to discover the correct substance, but sometimes it takes many. This practice results in containers partially full of unneeded chemicals.

Occasionally, the proper compound is discovered early in the process, leaving bottles of chemicals that were never opened.

HMC creates little waste compared to other companies. However, because of the testing performed in their research, some laboratories have been accumulating chemicals for up to 10 years. Occasionally the company returns a chemical to the supplier and must pay to dispose of it. This happened recently when HMC had to get rid of 5 cylinders of chlorine gas and paid 20,000 baht (US$500) to do so. To avoid large bills such as this, HMC often sells their leftovers cheaply as scrap material, or gives them away. Last year, over 70 containers of unused laboratory chemicals were donated to CU. Most were in their original containers and some were unopened.

There have been some informal exchanges between some of the factories in Mataput, but most are because the borrower can't acquire a chemical from a supplier in a given time. The borrower is always expected to either compensate for the exchange or return the substance later. This is especially common within the four HMC plants in the industrial park, as all the laboratory managers know each other.

Because HMC is part of a multinational corporation and is ISO 14001 certified, it is expected that chemicals it cannot exchange or donate will be disposed of properly. In addition to following the rules for disposal, HMC must follow all other regulations put forth by the US EPA and other national organizations. If it doesn't comply with the rules it faces large fines.

4.3.2.2 COMMERCIAL WASTE DISPOSAL

In response to the volume of waste being created by Thailand's industrial sector, the Ministry of Industry (MOI) has recently built the first hazardous waste treatment plant in Thailand. Located in Bangkhuntien Center, its purpose is to treat acid and alkaline wastewater containing heavy metals. In addition to this facility, this Ministry also built the Ratchaburi Landfill, which currently contains over 10,000 tons of hazardous wastes (Samarn, 28/1/00). In 1994, MOI joined with the private sector to form the General Environmental Conservation Public Company (GENCO). There are currently 16 inspectors to all the factories in Thailand.

Some assistance is provided to industry by the consultants of GENCO who currently provide companies with free site assessments. Companies improperly handling and disposing of chemicals are informed about services that GENCO can provide. Since GENCO is the only waste disposal organization in Thailand, companies that do not utilize its services are obviously not following regulations. When this occurs, GENCO informs the Ministry of Industry (Vorapinit, 3/2/00).

GENCO serves 6,000 factories currently, collecting approximately 308 thousand metric tons per year of Thailand's hazardous waste, and treating about 5% on-site. The remainder is separated and distributed to landfills and other disposal sites. Although the Ministry of Industry owns 25% of GENCO's shares, the company receives no government funding. The company receives assistance from part of an environmental fund and also takes advantage of investment incentives from the Board of Investment (BOI). It is a Thai firm, yet GENCO aims to be internationally competitive. For this reason, it follows many strict US EPA regulations and manifests all materials that it handles. GENCO is also the only company in Thailand with drivers who have hazardous waste transportation licenses. (Company Profile, 2000, 4).

Currently, GENCO operates two plants that dispose of chemicals: one in Samaedom, Bangkok and another in Mataput, Rayong. The facility at Samaedom was built by MOI as a demonstration plant in 1988 and deals with 100,000 tons of waste per year. It handles mainly electronics wastewater containing heavy metals, alkalis, and acids. GENCO's waste treatment process precipitates heavy metals and solidifies them in concrete, which is buried in the ground after passing a leeching test. GENCO's larger plant, located in Mataput, treats another 100,000 tons per year. It was designed by Waste Management International (WMI) to handle organic and inorganic wastes. Included on site is a US$4 million lab for analyzing the composition of wastes. At Mataput, stabilization methods are used to neutralize wastes. In addition, the plant often uses fuel blending which mixes organic wastes to form cheap fuel typically incinerated in cement kiln.

GENCO does not require a minimum quantity for treatment, or have a minimum price. However, service and transportations fees are the same for any quantity of material, making disposal of small quantities uneconomical.

HMC reported showing GENCO a list of laboratory chemicals that were to be disposed of. GENCO allegedly said that the substances could not be disposed of because it was inefficient to dispose of such small quantities of so many different materials. These chemicals unfortunately continue to sit in the laboratory because they were highly reactive and therefore couldn't be blended. GENCO does take most of HMC's production wastes, such as used lube oil and solvents used for cleaning their machines.

4.3.3 THE FUTURE WASTE MANAGEMENT IN INDUSTRIES IN THAILAND

By 2001, it is estimated that 2.8 million tons of hazardous waste will be generated in Thailand by industry each year. In 1986, this figure was only 0.53-1.12 million tons per year (Company Profile, 2000, 1). GENCO is now in the first stage of its long term plan designed to accommodate future production rates. It can currently treat 65% of the hazardous waste in Thailand. Untreatable wastes will be addressed in later stages of GENCO's master plan with new chemical treatment methods. Within the next two years there will also be two incinerators completed in Thailand, one built by the IEAT at the Bangpoo Industrial Estate and the other built by MOI (Company Profile, 2000, 2).

Partially because GENCO recognizes that universities such as CU are also a source of chemical waste, it has added Lab-Packing to its list of current services. This service would treat the chemicals behind Chemistry Building 1 at CU for 5-10,000 baht (US$125-250) per ton. Khun Vorapinit proposed that the cost could be reduced if chemical wastes from the whole IUCRC were collected and separated by type. He also suggested that CU set up a committee to organize waste disposal for their campus. This venture will also help companies such as HMC eliminate their unusable laboratory wastes.

Both GENCO and HMC were questioned in regards to the planned CU chemical exchange. Because GENCO is paid for disposing of wastes such as those that would be used in the exchange, it seemed unlikely that their response would be encouraging (Supawan, 12/1/00). However, GENCO seemed enthusiastic about its consultants recommending the exchange to companies when eligible chemicals were found. Khun Vorapinit also stated though that GENCO was unlikely to donate further services.

HMC responded to the proposal of an exchange with the point that "Chemicals are kept on the shelf for a long time and there are no disposal companies to deal with large numbers of small chemical containers," and "many of the companies [in Mataput] have been waiting for this project." The representative from HMC further stated that the company would be happy to donate chemicals to an academic institution but would probably want monetary compensation from another company.

CHAPTER 5: CONCLUSIONS

The conclusions described in this section had a direct effect on the implementation of the surplus chemical exchange, which is discussed in the next chapters. They govern the decisions that had to be made before the exchange could be implemented.

It was decided early on that CU does not have the facilities, staff, or funding to handle the storage and transportation of, and responsibility for a centralized exchange. As a result, SCECU will act bilaterally, handling only information.

As noted in section 4.1.4, all interviewees thought that the exchange was a good idea. Professors were enthusiastic about using it and representatives from government ministries appreciated the concept. However, since the staff and resources are limited, SCECU will at first be confined to the CU campus because it is apparent that there is a enormous need for such a program there.

The exchange should focus on laboratory chemicals instead of those from large-scale industrial processes because surplus chemicals are more useful at Chulalongkorn University. Wastes and byproducts, from both laboratories and industrial processes, will also be excluded from the exchange because most potential consumers deemed them unusable. In addition, the purity of such chemicals is an issue and would create problems for the exchange.

The commercial sector has a large number of research laboratories with many surplus chemicals. Since companies like GENCO focus on large volume industrial chemicals, these laboratories have no proper way to dispose of these materials. Consequently, an exchange program will also benefit industrial and governmental laboratories.

Requesting funding and assistance from the commercial sector will also be a part of future plans. GENCO currently does consulting and educational work for industries, advising them on how to dispose of their waste. This is an ideal situation for promoting the exchange and notifying industries about it. GENCO has indicated that it would be willing to help in such an endeavor. Other industries, such as HMC, already participate in occasional, informal exchanges through the Mataput Safety Association (MSA) to which they pay dues. MSA or other Thai industry groups might be persuaded to contribute some funding if they were included in the exchange.

Used solvents will be excluded from the exchange because there is little demand for them. They are inexpensive to purchase, and two out of three departments interviewed at CU already recycle their own solvents. It is recommended that departments that cannot recycle their solvents, such as those in the Faculty of Engineering, purchase the necessary equipment or find another department to assist them.

The Internet is the ideal method to publicly display a list of shared chemicals at CU. The number of computers available on campus is adequate for the staff to conveniently use. Preparations to run the exchange have already been made on the chemistry web server. A web page connected to a database will be used to post the exchange's list on the Internet.

None of the professors interviewed were concerned about keeping their research methods confidential, and so contributor contact information will be available on the SCECU website. This means that a user does not have to contact the exchange to acquire a chemical, making the exchange automated and easy to administer.

These conclusions and recommendations have shaped how SCECU will be designed. The implementation of the exchange is divided into four phases, which are summarized in Chapters 6 while issues that affect the feasibility of the exchange are discussed in Chapter 7.

CHAPTER 6: IMPLEMENTATION

This chapter describes the present status of the Surplus Chemical Exchange at Chulalongkorn University (SCECU) as of 29 February, 2000. Section 6.1 covers the organization of the exchange in its current form, with emphasis on participants, commodities, funding, staffing, and operation. The computer system infrastructure is detailed in Section 6.2 . Proposals for the future direction of the exchange are discussed later in the chapter.

6.1 ORGANIZATION

It was decided that SCECU would initially confine itself to the Chulalongkorn University campus rather than beginning with a large-scale operation. Due to the time limitations of this study, a temporary prototype system has been implemented. Although SCECU can help alleviate CU's disposal problems, later phases will offer further opportunities to benefit the outside community. The decision to expand slowly has some advantages. First of all, realistic goals were set and achieved to the extent of the project group's ability. Secondly, SCECU has a better chance to succeed in the future if it does not extend beyond the limits of its staff and facilities too quickly. Since this is the first chemical exchange to be carried out in Thailand, it was questionable whether the program would be accepted. It remains to be seen how well SCECU will perform even on a small scale, but evidence from this study showed that the chances of success are good. With a gradual implementation, industry and academic institutions can be included after a reputation of dependable service has been established.

For all of these reasons, SCECU has been designed with a four-phase plan. The current stage is *Phase 1*, which requires few financial or staffing resources. Characteristics of the chemical exchange can be divided into the main areas displayed in Table 6-1.

Table 6-1: Overview of the 4-Phase Plan

	Phase 1: CU Laboratories	Phase 2: External Laboratories	Phase 3: Expanded Influence	Phase 4: Industrial Byproducts
Initiation Date	29 February, 2000	January, 2001	Unknown	Unknown
Operation	Bilateral Consumer contacts generator	Bilateral Consumer contacts generator	Bilateral Consumer contacts exchange Exchange contacts generator	Bilateral Consumer contacts exchange Exchange contacts generator
Promotion	Passive	Passive	Active	Pro-active
Advertisement	Personal Contact Flyers Posters Email	Personal Contact Flyers Posters Email	Personal Contact Flyers Posters Newspaper Journals Magazines Seminars/Conferences GENCO Email	Personal Contact Flyers Posters Newspaper Journals Magazines Seminars/Conferences GENCO Email
Funding	Non-profit	Non-profit	Non-profit	Profit
Fees	None	None	Advertising	Advertising Listing Membership Transaction
Assistance	CU	CU Government Grants	CU Government Grants NGOs Advertisement Revenue, International Environmental Agencies	CU Government Grants NGOs Advertisement Revenue, International Environmental Agencies Revenue from Fees
Staffing	1 Volunteer Chemistry Department Graduate Student	1 Part time Chemistry Department Employee	1 Full time Chemistry Department Employee	Multiple full time staff
Participants	CU	CU University Labs Government Labs Commercial Labs	CU University Labs Government Labs Commercial Labs	CU University Labs Government Labs Commercial Labs Commercial Factories
Services	Chemical List SCECU Web Site	Chemical List SCECU Web Site SCECU Newsletter	Chemical List SCECU Web Site SCECU Newsletter Advertisement Consultation	Chemical List SCECU Web Site SCECU Newsletter Advertisement Purity Testing Catalog Consultation Credit/Debit System

6.1.1 PHASE 1: CU LABORATORIES

In its current stage, SCECU is capable of servicing the Chulalongkorn University (CU) campus only. Participants include selected departments from the Faculty of Science, the Faculty of Engineering and the Petroleum and Petrochemical College. Within these faculties, all 12 relevant departments have been informed about the exchange. SCECU currently lists chemicals from the Chemical Technology Department and the Chemical Engineering Department. Chemistry will soon be submitting its lists of donations and the remaining nine eligible departments will follow suit. The contents of Table 6-2 represent just a small fraction of the anticipated contributions to SCECU.

Table 6-2: Chemicals Contributed by CU Departments

Department	Chemicals in Department Stock (approximate)	Chemicals Contributed to SCECU (approximate)
Chemistry	2000	0
Chemical Technology	100	12
Chemical Engineering, Biochemical Testing Lab	Unknown	50
Chemical Engineering, Analytical Testing Lab	500	200
Biology	Unknown	0
Biochemistry	Unknown	0
Materials Science	Unknown	0
Molecular Biology	Unknown	0
Environmental Engineering	Unknown	0
Mining and Petroleum Engineering	Unknown	0
Water Resource Engineering	Unknown	0
Petrochemical College Departments	Unknown	0

As discussed in Chapter 5, commodities that can be exchanged on SCECU include only surplus laboratory chemicals. This excludes reusable chemicals like reaction byproducts and chemical wastes such as hazardous compounds from factories (see Chapter 2 for definitions). There are no plans to change this policy until Phase 4, since only laboratory chemicals are useful on the CU campus.

SCECU is classified as a passive exchange in this phase. Since it lacks a permanent staff, promotion will be limited to printed flyers, word of mouth advertising and possibly email to campus participants. Limited personnel time restricts it from directly educating others and encouraging chemical reuse and proper disposal. Within the first phase, SCECU's only objective is to facilitate the exchange of university chemicals. In doing so, SCECU will be able to build a strong foundation and reputation at CU. Later phases will lend more variety to its role in the community.

At this stage, SCECU requires no funding. Dr. Supawan Tantayanon of the Chemistry Department will be selecting a graduate student to volunteer his or her time each week to update the list. The maximum weekly requirements are estimated to be less than five hours. If SCECU's administrator performs his or her duties effectively, SCECU can have a continuously updated listing published on the Internet and keep accurate records on past transactions. The following is a list of necessary tasks for the exchange operator:

1. Perform administrative tasks
2. Visit CU departments to obtain a contribution list
3. Follow up with departments monthly to request more donations
4. Distribute current chemical list to CU Departments with email or personal contact
5. Verify accuracy of list regularly

Figure 6-1diagrams the communication path through which SCECU facilitates the transfer chemicals from generators to consumers, while keeping track of these transactions.

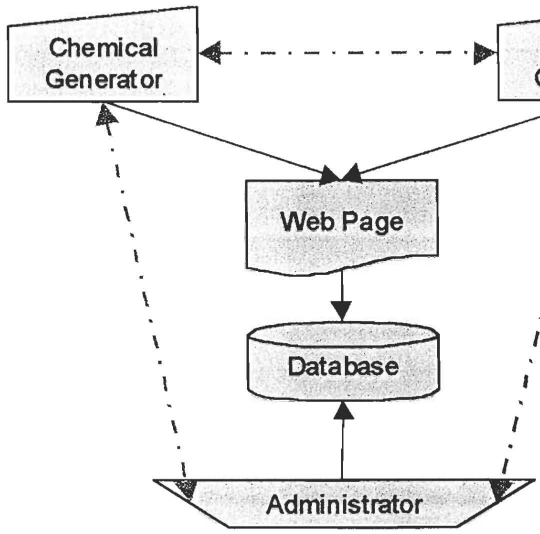

Figure 6-1: Communication Paths among Exchange Participants

6.2 *COMPUTER SYSTEM*

The computer system used for SCECU has database and World Wide Web components. The database, accessible by the administrator only, stores every entry in the chemical exchange list. In order for interested parties on campus to view or contribute chemicals, there is a web page acting as a user-friendly entry point into the system. The following sections go through each component individually. Table 6-3 presents the functions that each of these components carry out. *Figure* 6-2 illustrates the factors involved in an actual transaction, including the interaction between the web page and the participants

Table 6-3: Computer System in the 4-Phase Plan

	Phase 1: CU Laboratories	Phase 2: External Laboratories	Phase 3: Expanded Influence	Phase 4: Industrial Byproducts
Weekly Tasks	Verify contributions Verify removals Distribute lists Collect lists Verify accuracy of list Seek funding sources	Verify contributions Verify removals Distribute lists Collect lists Verify accuracy of list Seek funding sources	Verify contributions Verify accuracy of list Seek advertising sources Seek users Seek funding sources	Verify contributions Verify accuracy of list Seek advertising sources Seek users Seek funding sources
Web Page Functions	Contribute Remove List Search Information Links	Contribute Remove List Search Information Links	Login, Manage Contributions Order List Search Information Links	Login Manage Contributions Order List Search Information Links
Contribution Procedure	1. Visit SCECU web site 2. Fill out form	1. Visit SCECU web site 2. Fill out form	1. Visit SCECU web site 2. Create an account 3. Login to account 4. Fill out form	1. Visit SCECU web site 2. Create an account 3. Login to account 4. Fill out form
Acquisition Procedure	1. Visit SCECU web site 2. Search for chemicals 3. Locate chemical 4. Record corresponding contact information 5. Contact Donor	1. Visit SCECU web site 2. Search for chemicals 3. Locate chemical 4. Record corresponding contact information 5. Contact Donor	1. Visit SCECU web site 2. Search for chemicals 3. Located and select desired chemical 4. Create an account 5. Login to account 6. Verify order	1. Visit SCECU web site 2. Search for chemicals 3. Located and select desired chemical 4. Create an account 5. Login to account 6. Verify order

6.2.1 DATABASE COMPONENT

Databases are electronic filing systems that can store information in a searchable form. In order to allow users to dynamically interact with the list of compounds offered by SCECU, all the entries have to be stored electronically. A database allowed for easy integration with a World Wide Web server so information could be posted on the Internet. The main advantage of SCECU's database over a simpler spreadsheet or paper file is the opportunity it presents for the user to find specific records and enter their own contributions.

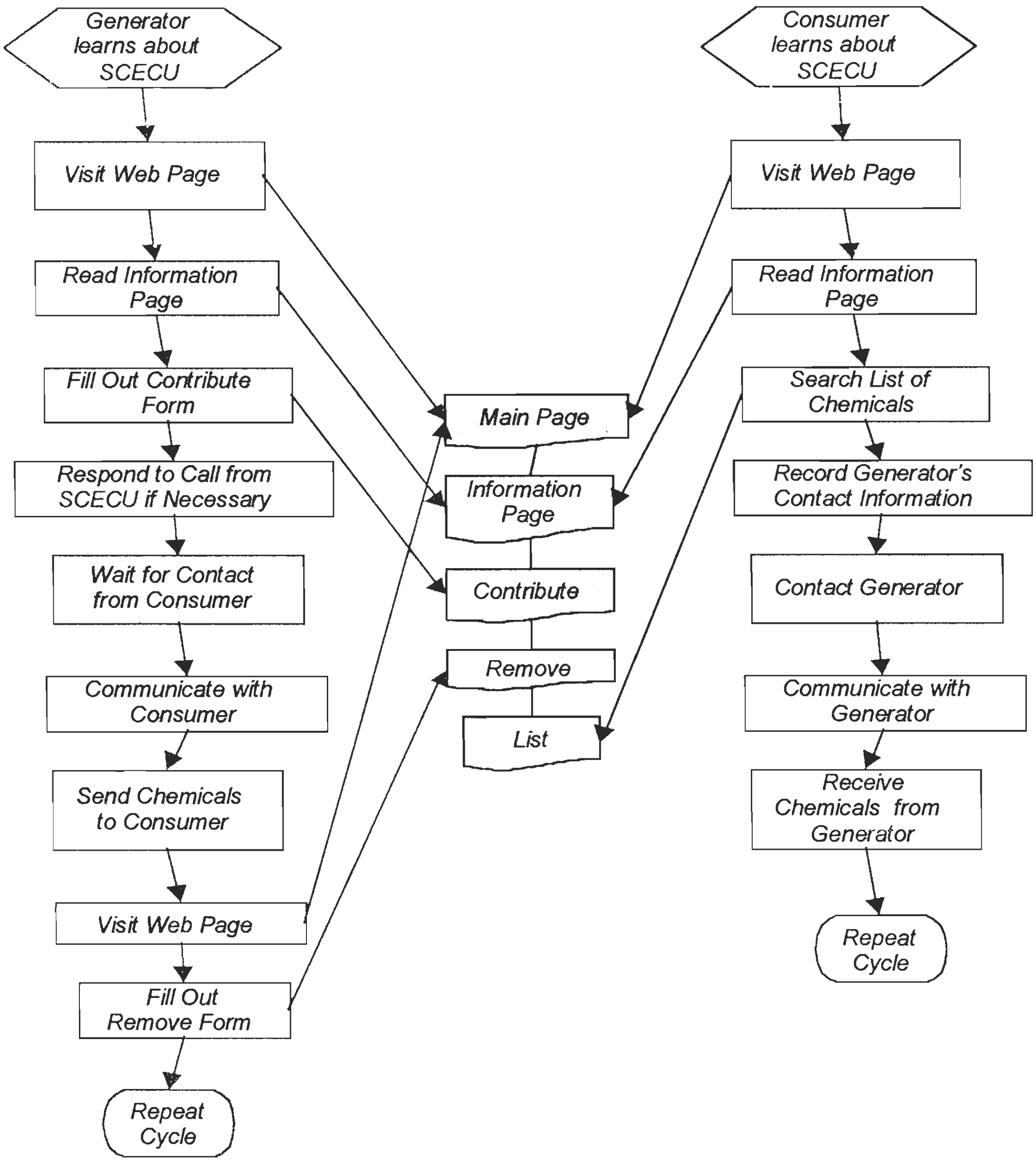

Figure 6-2: Transaction Process

Due to its widespread use and the likelihood that future administrators will be familiar with the application, Microsoft Access 97 was used to construct the database. Appendix L contains relevant information for the SCECU administrator.

6.2.1.1 *DESIGN OF THE DATABASE*

Microsoft databases contain objects called tables, queries, and forms. *Tables* store records such as the list of chemicals and their owners. *Queries* display specific sets of information extracted from tables by using a database language called Simple Query Language (SQL). Although the SCECU database does have pre-made queries, the web page also generates customized queries each time a user searches the database to display a portion of the entire chemical list.

Forms were created as an easy means to modify the chemical listings in the database. The following sections provide an explanation of the function of the objects within the SCECU database.

6.2.2 WEB PAGE

Developing a web page for SCECU that could communicate with the database required that Active Server Page (ASP) scripts be written. VBScript *ASP scripts* run on the web server each time a user tries to search the SCECU database or submit forms for contributions or removals. The server establishes a link to the database through ODBC, sends SQL, and dynamically generates the web page based on the results. Figure 6-3 and

http://chemistry.sc.chula.ac.th/SCECU. When users go to this URL, the main page greets them (see Figure 6-4). On the main page there is a navigation bar to the left containing links to the functions of the web page. Personal telephone numbers and email addresses of important SCECU affiliates are also supplied. Essential facts for the SCECU administrator are in Appendix L.

Table 6-4 portray the integration of technologies used in this implementation.

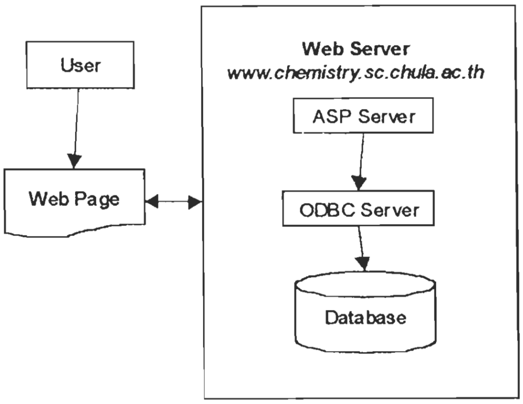

Figure 6-3: Web Infrastructure

http://chemistry.sc.chula.ac.th/SCECU. When users go to this URL, the main page greets them (see *Figure 6-4*). On the main page there is a navigation bar to the left containing links to the functions of the web page. Personal telephone numbers and email addresses of important SCECU affiliates are also supplied. Essential facts for the SCECU administrator are in Appendix L.

Table 6-4: Web Page to Database Communication

Description	HTML File	ASP File	ODBC Name	Database Table
Main Page	default.html default.htm SCECU.html	SCECU.asp Title.inc NavBar.inc		
Information		Information.asp Projects.asp Summary.asp		
Contribute		Contributepage.asp Contribute.asp	SCECU	tbl_contribute
Remove		Removepage.asp Remove.asp	SCECU	tbl_remove
List and Search		List.asp	SCECU	tbl_list

The SCECU web page is viewable at by clicking on links from the navigation bar, the user is taken to different pages. Table 6-5 has a list of Navigation Bar choices and their functions.

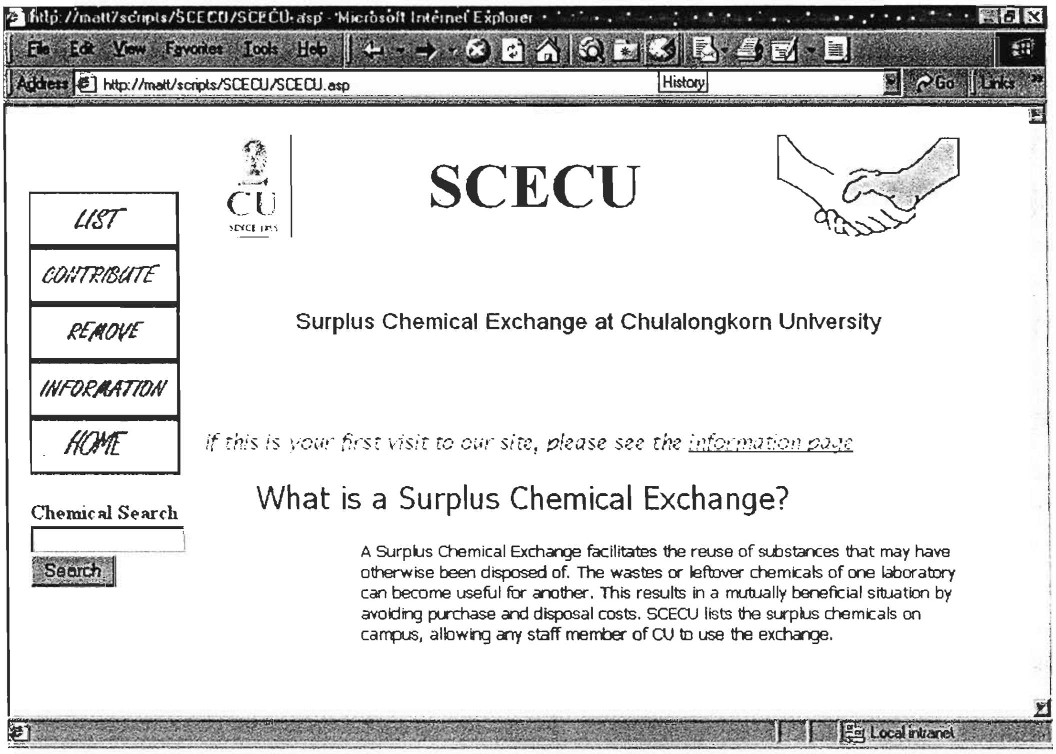

Figure 6-4: SCECU Homepage

LIST PAGE

The list page (see *Figure 6-5*) is a multipurpose page that allows SCECU users to easily view the entire list or search for individual chemicals based on several criteria. The available search fields are shown, in Table 6-6.

Table 6-5: Options from Main Page

Option	Functionality
List	View a complete list of items
Contribute	Request that a new chemical be added to the database
Remove	Request that a chemical be removed from the database
Information	View information on the SCECU project
Search	Search the list
Home	Return to the home page

Table 6-6: Example Fields

Field	Example Entry
Chemical Name	Toluene
CAS#	654376
SCECU#	004
Date Listed	02 March 2000

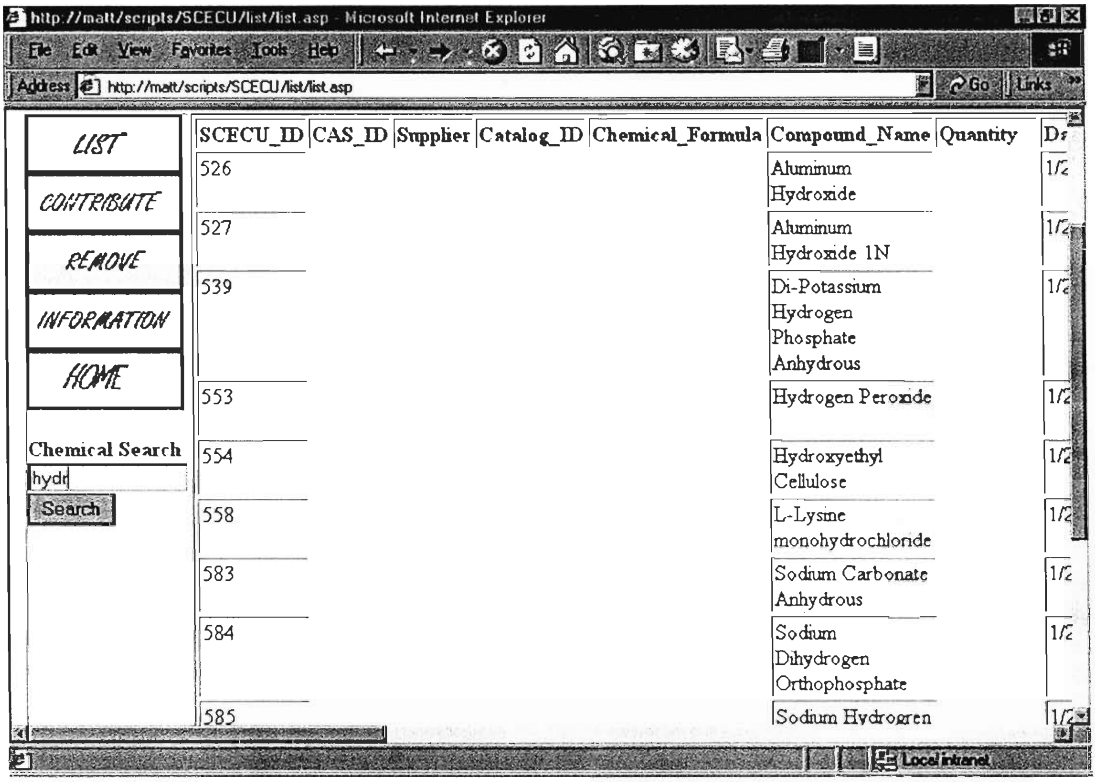

Figure 6-5: List Page

CONTRIBUTE PAGE

The contribute page (see Figure 6-6) is a form with 20 fields to be filled in by a participant of the exchange each time he or she adds a chemical. It is necessary to fill in certain required fields, which are noted on the page. At the bottom right, there is a *submit* button and a *clear* button. *Submit* sends the request and *clear* blanks all fields in the form. The *submit* button sends the data entered on the page to the SCECU database and provides the user with a "thank you" message. Later on, the SCECU administrator reviews contributions and verifies missing information. He or she may need to call the donor department to verify the accuracy of ambiguous entries.

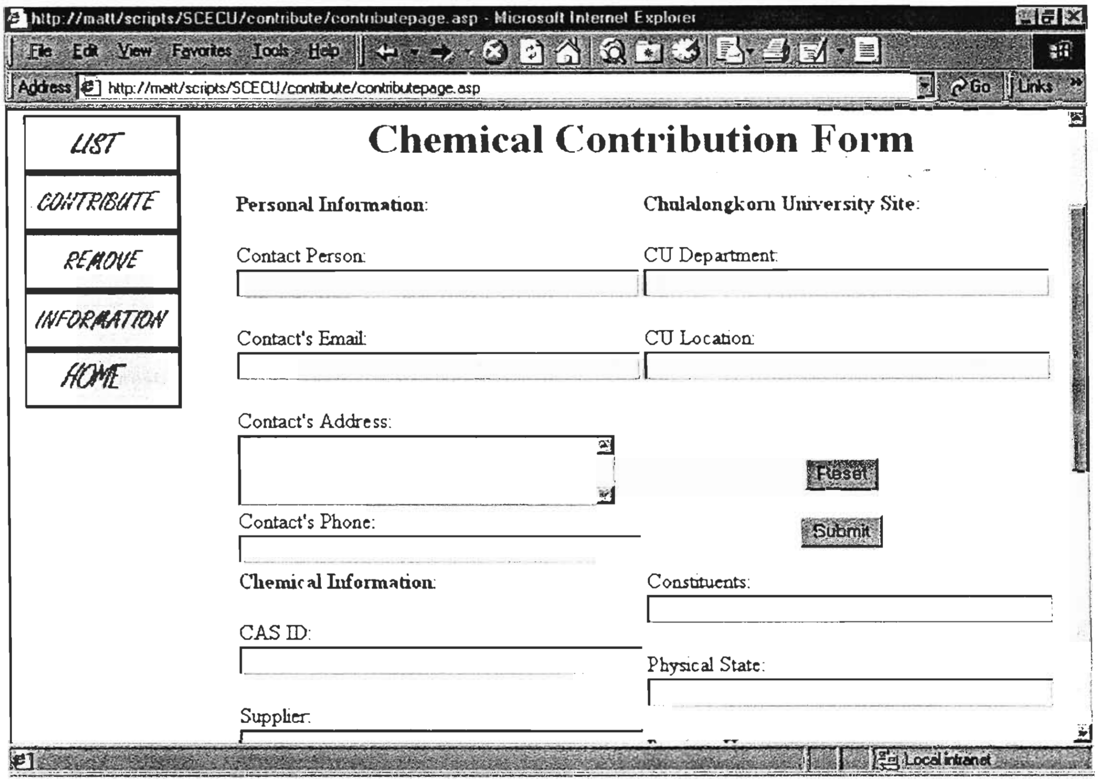

Figure 6-6: Contribute Page

REMOVE PAGE

This page is a form similar to the contribute page and must be filled in with an identical process (see Figure 6-7). Once a request to remove an item is sent, the SCECU administrator uses a database form to accept or deny it. The removed items are stored in tbl_archive along with an additional field that states a reason for the removal. This information can be analyzed later to assess the effectiveness of SCECU.

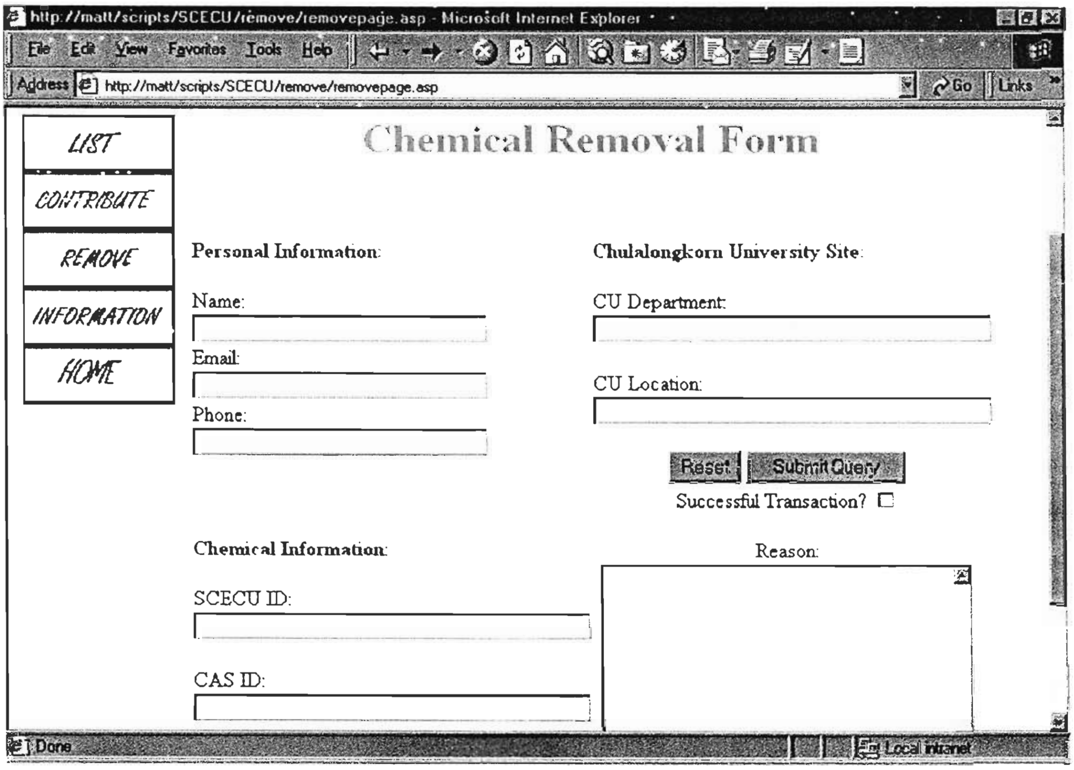

Figure 6-7: Remove Page

INFORMATION PAGE

To learn more about SCECU, the Department of Chemistry at CU, the *Surplus Chemical Exchange at Chulalongkorn University* Interdisciplinary Qualifying Project (IQP), or the project program at WPI, the user can visit this page (see *Figure 6-8*). This page also contains instructions on how to use the SCECU website.

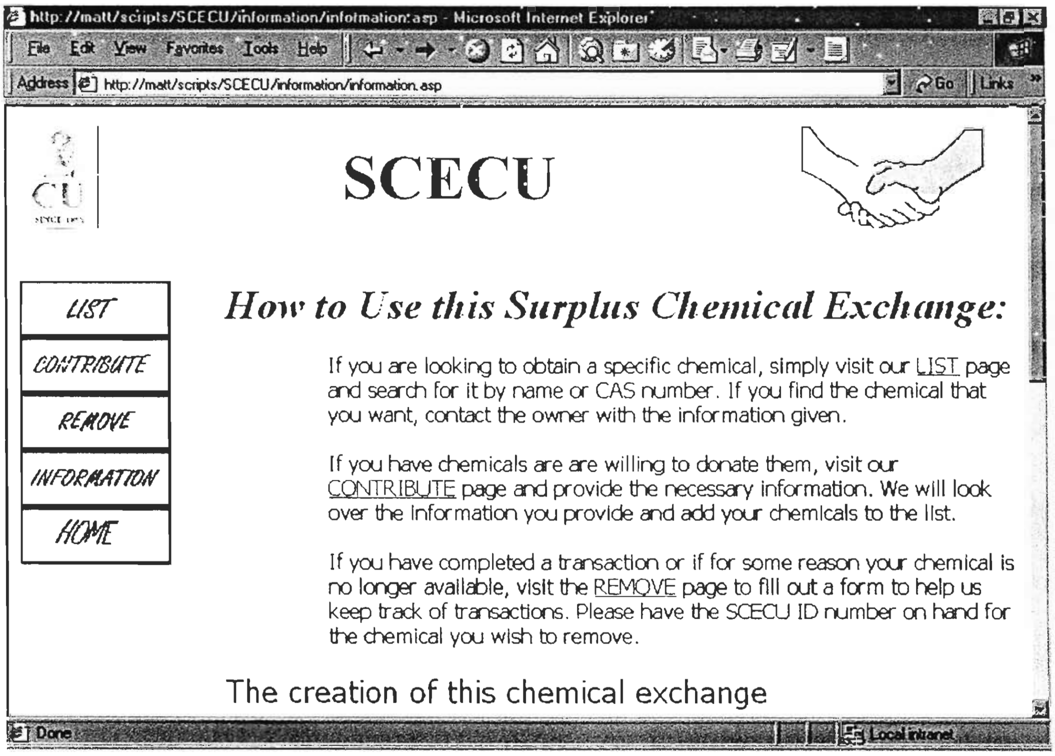

Figure 6-8: Information Page

6.3 *PHASE 2: EXPANDING BEYOND CU*

To expand the customer base of the Surplus Chemicals Exchange, it is recommended that other laboratories outside of CU become involved in the exchange. A larger market will provide a better variety of chemicals and increase participation.

Laboratories in other universities, in Bangkok government facilities, and commercial plants should all be targeted. Section 4.3.1 showed that they are likely candidates for chemical exchange. Universities within the IUCRC such as KMUTT will be informed about the procedures for contributing and acquiring chemicals from SCECU. Industrial estates at Mataput and Bangpoo contain many commercial research labs with an abundant supply of surplus chemicals.

In Phase 2 most characteristics of the exchange's operation will not differ from the original setup. The web page and database will not change form. SCECU will continue to operate bilaterally, allowing consumers to check the chemical listing on the Web and initiate contacts and transport on their own. Although a part time Chemistry Department employee will be permanently in place at this point, no active promotion will be done. The increased number of participants will demand most of the employee's time.

It will be crucial to keep careful records of all transactions in the database. Proving that SCECU can successfully reduce chemical pollution may be necessary to attain government grants. Further funding from the government or corporate sponsors will allow for a paid staff member that can visit outside chemical generators. The project will be more widely used in later phases if the exchange can be proactive. As evidence from US materials exchanges has demonstrated decisively.

6.4 PHASE 3: EXPANDING CAPABILITY

The objective of Phase 3 is to expand the computer system by adding features that make the operation more efficient. Staff responsibilities will also be to intensified to provide better service for the increased number of participants enlisted during Phase 2.

Potential for publicity will also improve through collaboration with companies such as GENCO. As mentioned in section 4.3.1, a mutually beneficial advertising venture could be set up wherein GENCO refers its customers to SCECU when they have reusable chemicals. SCECU could act reciprocally by advising users who have been unsuccessful at sharing their chemicals through the exchange to dispose of them properly with GENCO.

During Phase 3, advertisements in newspapers, journals, and other literature could be useful to spread word of SCECU, encouraging more chemical generators and consumers to take part. SCECU can also obtain advertising revenue through rotating carefully selected banner ads on its web page, which, depending on how often the site is visited, could be lucrative. At the least, disposal companies or organizations that recycle wastes could place permanent advertisements on the web page for a fee.

As with materials exchanges in the US, active promotion will be very important. Since the exchange was organized to help solve chemical pollution problems and is run from the Chemistry Department at CU, it is likely to have a knowledgeable staff able to provide many consulting and educational services to the community. For instance, SCECU will be able to advise companies about which waste they can exchange and which should be disposed of. Printing literature and teaching classes on waste minimization might be considered as well.

A major advance in Phase 3 will be an automated system whereby consumers will no longer seek out chemicals based on contact information on the web page. Instead, users will be able to login to the web site and select individual chemicals to order. After submitting an order request, the computer system will automatically inform the contributor by email that their donation has been selected. Transportation can be arranged by the donor or the new user.

Methods of transport must comply with government regulations, which can be expensive. The cost of transportation can be assigned to the consumer if necessary.

Among improvements to the electronic listing system will be its integration into CU's future centralized inventory system. This will allow new orders from departments on campus to first check SCECU before processing request for new chemicals.

Adding the ability to login to the web page yields several advantages. First of all, contributors will be able to manage their donations online without filling out online removal requests. They could delete chemicals or change the quantity or name of existing donations without involvement of the SCECU staff. Increased automation is necessary to make SCECU run efficiently due to the large number of chemicals that are anticipated for Phase 3.

6.5 PHASE 4: ADDING INDUSTRIAL BYPRODUCTS

In several years SCECU may grow into a comprehensive chemical reuse program. In this phase the exchange will still operate bilaterally, but will take a greater role as a middleman. When a user requests a chemical, the exchange will contact the contributor and transport the material. Byproducts of industrial products will also be added to the list of exchangeable materials, and factories that produce them to the participants.

The operational expenses and added transportation costs of the exchange will be partially funded by fees. These can be charged for listing a chemical, for successful transactions, or for membership. A catalog of substances available in which companies would pay to place ads could be published in this phase. Advertisements on the web page will also continue to yield revenue. Income may also come from international assistance or government funding. With the added service of transportation, the exchange can become profitable in this phase.

In phase four multiple full time staff members can be added which will allow for additional services. For a fee, the user can have chemical byproducts tested at CU to determine their composition before transfer.

The web page will retain its current features, and a login function will be added. Participants will have an account on the system, which will allow them to manage their contributions, such as removing one or changing the amounts available. Donors will also be able to add to their list of contributions without reentering contact information. The search function, information page, and links will also be improved and updated.

The database will remain the same with the addition of a table of accounts and one of subscribers. Once these are incorporated into the system, information submitted by a party applying for an account will be placed in the subscribers table, which the staff will review before issuing an account. The managers of the database, in addition to verifying contributions and removals, will be able to manage and control data concerning the user's accounts if necessary.

CHAPTER 7: PROJECT OVERVIEW

Chapter 7 presents an overview of the *Surplus Chemical Exchange of Chulalongkorn University* IQP. In addition to evaluating the feasibility of chemical exchange at CU, this chapter appraises the project's efforts to improve chemical management.

7.1 *THE FEASIBILTY OF CHEMICAL EXCHANGES AT CU*

The success of a reuse program is generally measured by how much it is used. In the case of SCECU, this would include both the number of substances listed and the number of transactions completed. The success of SCECU will be dictated by the cooperation of participants and the capabilities of the exchange. Discussions in the following subsections address one or both of these factors. A summary of these sections can be seen in *Figure 7-1.*

7.1.1 REASONS FOR OPTIMISM

There were many indications that a surplus chemical exchange in Thailand would be widely encouraged, beneficial to its community, and utilized frequently. The first signal was that those interviewed were open to the idea of exchange. Almost all of the interviewees, after being told the purpose of the project, volunteered the opinion that they thought it was a great idea. This included individuals from CU, the government, private industry, and KMUTT.

The many surplus chemicals on shelves in CU departments demonstrated

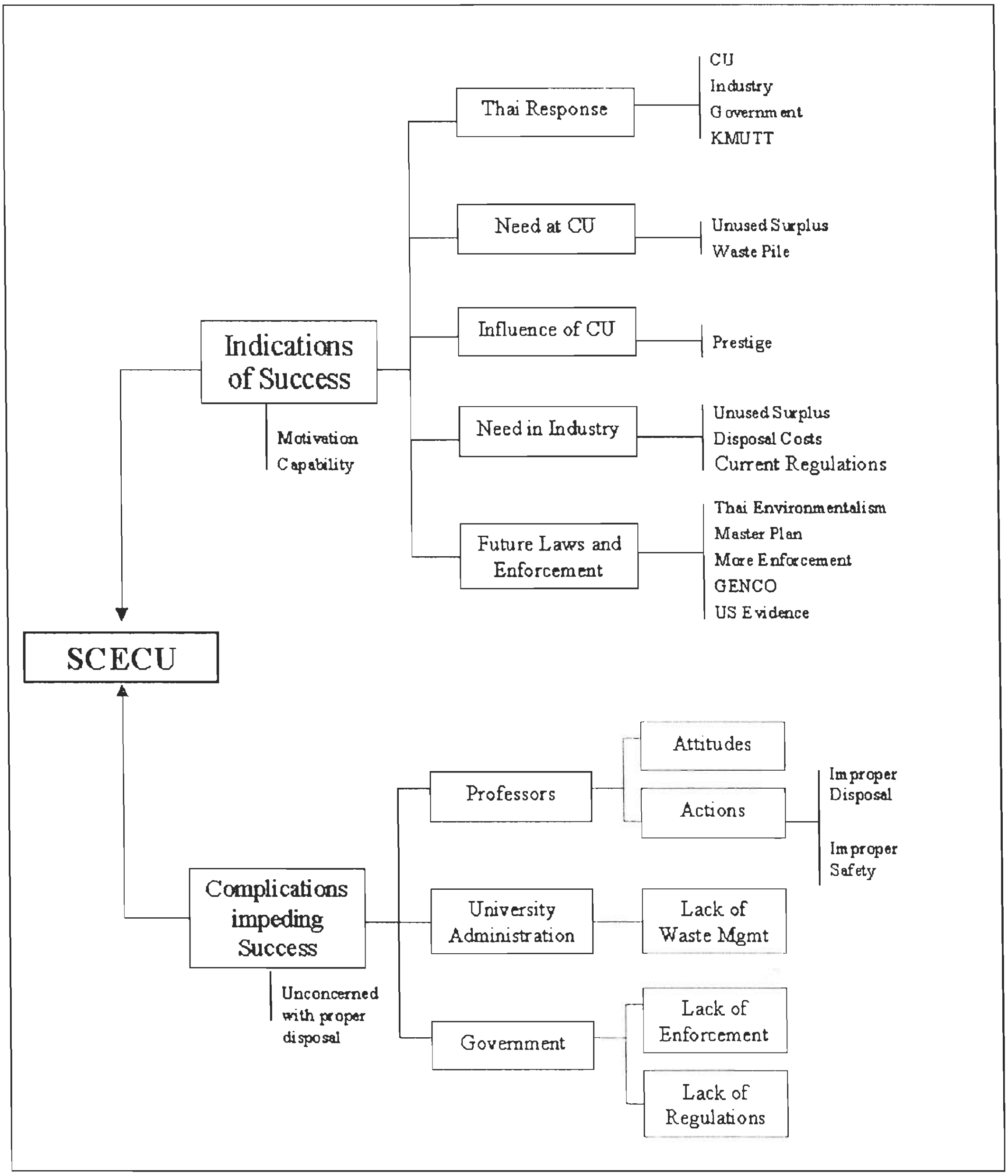

Figure 7-1: Forces and Factors affecting Exchange Feasibility

a need for an exchange program. Some of the chemical stockpile accumulating behind Chemistry Building 1 consists of once usable surplus.

CU provided many of the components necessary for SCECU to operate. The staff, electronic capabilities, and expertise were all in place. With its prestige and status, the university can build a strong foundation from which SCECU can expand.

Industry representatives reacted positively towards the prospect of chemical exchange since its need in industry is apparent. Although there are currently laws governing the treatment and disposal of hazardous wastes, their enforcement is minimal. Some companies wish to comply with existing regulations, but not all can afford to follow the procedures. An exchange could be an alternative to disposal for companies such as HMC, which holds a substantial amount of surplus laboratory chemicals. Businesses could comply with the law by swapping substances instead of paying to dispose of them.

Environmental awareness is increasing in Thailand. This consciousness will create growing pressure on the government to produce noticeable changes. The government is presently creating a Second Master Plan, to take effect in 2001 and address some of these issues. GENCO is also increasing its treatment capacities to enable proper treatment by more companies. If enforcement measures increase, as they have in the US, disposal costs will encourage companies to participate in SCECU and similar reuse programs. A similar period of environmental reform occurred several decades ago in the US and caused the creation of over one hundred exchanges.

7.1.2 COMPLICATIONS IMPEDING SUCCESS

Despite the likely success of SCECU, it is possible for it to not do well. Since most necessary components are in place, failure would be the consequence of indifference at CU toward waste disposal. If those in charge of chemical management do not feel compelled to use the exchange, it will not be utilized.

Despite interviews that indicated concern CU professors for the effects of chemicals on the environment, actions on the part of both students and staff may contradict this. Neither students nor professors felt that chemical waste was a major contributor to pollution in Thailand. However, their view could be that chemical pollution is a problem, but not significant when compared to other forms of pollution in Bangkok. Actions demonstrating lack of concern or awareness were most apparent in student practices. Graduate students indicated that some of their peers do not dispose of their chemicals properly out of ignorance or disinterest. This attitude may point to a lack of concern demonstrated by professors. At CU, regulations, disposal training, and education about the effects of chemicals in the environment were all absent. In response to these issues it is recommended that a class be set up for both students and professors to teach proper disposal practices. Admittance to a laboratory should require the completion of such a course.

Lack of concern may not be the only reason why professors don't apply more energy to safety and disposal. The administration of CU may also be a factor. Although it was proposed in the 1996 IQP on Chemical Safety at CU, an adequate chemical waste management program has not been created thus far. CU is an immense university with a large administration that has possibly been unable to address this problem directly. The individual faculties and departments that deal with chemicals may lack communication, funding, or resources to make chemical waste management a high priority. Following the 1997 economic crash described in Chapter 2, many of the institution's projects have no doubt been postponed.

The final entity influencing waste generators and consumers to participate in SCECU is the Thai government. No regulations currently govern chemical disposal for universities. For that reason, CU has not been pushed to resolve the improper disposal of their chemical waste. KMUTT, in contrast, has an effective chemical waste management system even in the absence of requirements. Therefore, regulations may not always be a prerequisite to environmentally conscious behavior. In CU's case, government regulation appears to be a necessary stimulus in order to encourage interest.

There are regulations governing the actions of industries; however, these are not well enforced, nor are the penalties very harsh. Currently, there are 16 inspectors responsible for all of the factories in Thailand. Dr. Yaron Yoel of GENCO proposed that more inspectors be hired. Similar to the creation of university regulations, enforcement of existing industry regulations would encourage participation in the exchange.

7.2 OVERALL CONCLUSIONS

The *Surplus Chemical Exchange of Chulalongkorn University (SCECU)* was initiated through the efforts of many dedicated members of the Chemistry Department. After considering the chemical waste disposal situation at CU, the project group designed SCECU to fit with the technological, financial, and motivational situation at this Thai university.

Operating the exchange will be an important step for CU. The university's excellent reputation will help SCECU to earn trust in the services it provides. The Surplus Chemical Exchange is a model for waste minimization because it facilitates the reuse of materials. As regulations grow, SCECU can only become more popular. Universities and commercial factories alike will need more services like a chemical exchange. As has happened in the United States, more materials exchanges will be created to respond to society's demand for environmentally conscious alternatives to landfill and incineration.

The benefits of the SCECU proposal extend beyond its subject matter as an Interactive Qualifying Project (IQP). It helped the project group to gain a more genuine interest in communicating across two very dissimilar cultures. The generosity of Thai people, coupled with their respect for foreign advice, allowed SCECU to be implemented smoothly. The exchange is anticipated to have a lasting affect at Chulalongkorn University. It will ultimately assist Thailand to maintain a sustainable industry, improving human health and environmental quality.

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To understand the motivation to create chemical exchanges in chemical consuming groups, a number of resources were utilized. A number of subjects of inventory, handling, transportation, storage, and disposal were studied to obtain a clear picture of current practices. Current waste minimization techniques were reviewed as well. Referenced web sites, literature, and university professionals portrayed US disposal practices. In Thailand, this knowledge was gained primarily through interviews with related ministry representatives, private agency employees, students, and CU and KMUTT professors. A list of these sources is provided below.

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Thailand and the Environment

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APPENDIX A: HANDLING OF HAZARDOUS MATERIAL

MANIFESTING

Waste must be manifested when transported from any location. In order to do this, necessary pick-up forms must be obtained and completed, accurately identifying the waste chemical as well as the quantity. This manifest is then forwarded to the EPA.

LABELING

Each container of hazardous waste must be labeled with the words, "Hazardous Waste," and have a completed waste tag attached. The waste tag should include pertinent information found on a Material Safety Data Sheet (MSDS); specifying name, concentration, purity, hazardous characteristics, date the chemical was obtained/opened, and shelf life. An exception to this rule is individual small bottles of DCCP if still in the original container.

ACCUMULATION TIME

Chemical wastes should not be accumulated for longer than the EPA allotted amount of time. This amount of time is determined by the EPA through the classification of the waste generator. These characterizations (defined previously) yield maximum storage times of 360 days for very small, 180 days for small, and 90 days for large generators. Each mixed container should be labeled with a tag which gives the accumulation start date and chemical constituents.

COLLECTION AND STORAGE

Compatible wastes should be collected and condensed i.e., halogenated with halogenated, and non-halogenated with non-halogenated. In addition to this, waste should be separated by *oxidizers, corrosives, flammables, toxins, and reactives*. Furthermore, they should be stored in strong, air-tight containers in a secure area that is weather protected, as well as ventilated, and temperature monitored. Lids should be kept tightly secured when not in use. Typically, bulk chemical wastes are stored in 55-gallon drums made of fiber, metal, or polyethylene, as appropriate.

WASTE MINIMIZATION

It is advisable to develop methods to try and recycle wastes or to reduce waste volume and toxicity. Also, when possible non-hazardous or less toxic chemicals should be substituted for hazardous chemicals. In addition, only the amount of chemical needed should be purchased.

TRAINING

Personnel who handle hazardous waste or prepare it for shipping should receive training in proper handling procedures and emergency response procedures. (Michigan State University, 1999)

APPENDIX B: PURITY TESTING AND DISTILLATION DETAILS

A great deal of discarded chemicals are the products of teaching laboratories. Through student experimentation, large volumes of solvents are used and then become waste. In addition to this, student reaction products are also disposed of. Some university chemical waste exchanges have found that, by recycling these products, a good deal of waste is eliminated. For secure re-use of these wastes a certain degree of purity must be ensured.

Acceptable purity can be determined through use of a series of tests. For solids, simple analytical purity testing can include melting point measurements. Further verification involves dissolving the solid in an appropriate solvent and using chromatographic or spectroscopic analysis on the resulting solution. These techniques include thin layer chromatography (TLC), gas chromatography (GC), column chromatography, infared spectroscopy (IR), and nuclear magnetic resonance spectroscopy (NMRS).

If the desired purity is not met, it is possible to "cleanse" the chemicals if the waste exchange group, the chemical donor, or the chemical recipient desire to invest time do so. Solids can be easily reduced to liquid form and recrystallized for improved quality. Liquids, particularly solvents, can be recycled. The simplest and most economical way to do this is through distillation techniques, when appropriate.

Several manufacturers of distillation apparatuses were contacted regarding appropriate set-up for a large university chemical exchange. B/R Instrumentation responded with very pertinent information regarding distillation.

B/R has reportedly been successful in getting many government, industrial and academic organizations to recycle their waste solvents. Once these groups get started, the advantages have been decidedly very obvious, as most laboratory solvents can be recycled.

It has been found that waste segregation is the key to making a program work. The reason is simple; it takes much less time and money to have people keep their waste streams separate than to have a distillation system do the work. Each solvent from a certain process should be collected and stored as a single waste stream. Different wastes usually should not be mixed together.

The solvents themselves may be collected in a variety of containers. Sometimes they are collected in the original containers, other times they are collected in plastic, metal or glass containers depending on the solvent. For instance, cheap metal or plastic containers are often adequate for solvents like hydrocarbons, alcohols and other less aggressive solvents. These containers can be obtained inexpensively in a local hardware store. Other solvents such as chlorinated solvents are more commonly stored in glass containers.

Once the wastes are successfully segregated, they should be recycled in the distillation system according to a preset protocol. The recycling process itself can proceed at anywhere from 0.5 to 5 liters per hour depending on the solvent, the degree of contamination, and the desired purity after recycling.

The purity of the recycled solvents that can be recovered depends on the specifics of the type of contaminants, and quantity of those contaminants. In other cases, the solvent can be purified to pesticide or electronic grade if desired. In other cases the solvent can be purified to a laboratory grade. There are some mixtures that can not be recycled back to their original purity due to the presence of azeotropes between the components. Generally speaking, the recycled material may be used in the same process or it may be used for an application that requires a lower purity. Usually however, the recycled material is assessed to validate the purity before reuse.

The B/R recommended apparatus is a 9600 spinning band distillation column. The price range of this product can range from $7,500 USD and up. The important features of this distillation column are as follows:

- 50 theoretical plates (excellent separating power)
- very small column hold up (very little solvent left in the column after the distillation)
- rugged and easy to use
- good track record for this application
- available in fully automatic, semi-automatic and manual versions

Spinning band distillation systems are ideal for use for recycling multiple solvents. Their high efficiency and low column hold up make change over between solvents quick and easy. For most changeovers, a small portion of the next solvent to be recycled is rinsed through the column or is distilled quickly to rinse out any residue from the previous material. For very volatile solvents, purging the column with dry air will remove any residue and make the column suitable for use with the next solvent.

There are some specific cases where the spinning band would need to be changed when going from one solvent to the next. If more than one distillation column is owned by a laboratory, typically only certain columns are used for certain solvents to avoid this problem.

Implementation of a solvent recycling program has been found to take two forms. The first is to put recycling systems in each laboratory and let the people in the lab recycle their own solvents. This approach is convenient because each lab has direct control over the process. Unfortunately the purchase of such equipment can be extremely expensive.

The second approach it to put someone, perhaps in the environmental, health, and safety department, in charge of a centralized solvent recycling area where all the reusable solvent is recycled and stored. This is usually more efficient and can yield more savings if managed properly. By using this approach, the Health and Safety Administrator can monitor which chemicals can be distilled safely and which should be deposited into the waste stream. (VanTreiste, 1999) In the case that the solvent be deemed disposable, the paths it might follow are discussed in the following section.

APPENDIX C: GOVERNMENT REGULATIONS

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

The RCRA is in place to ensure that wastes are properly managed and tracked. If a waste exchange does not generate, transport, treat, store, or dispose of hazardous waste, they are not subject to RCRA regulation. This act is still of concern for any exchange because the individuals and corporations that use waste exchanges are potentially impacted by RCRA regulations.

Generators are subject to manifest, pre-transport, record-keeping, and reporting, and land disposal restrictions. The ninety-day limit on hazardous waste storage makes the speed of the transfer process very key. Exchanges tend to be a slow route and can be incompatible with the need for corporations to disperse their wastes as quickly as possible. (Industrial Waste Exchange, 1996, Ch. 7)

COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT (CERCLA)

CERCLA covers liability on specific persons for cleanup costs, response costs, and damages to natural resources. The *hazardous substances* included in this act are, but are not limited to, those considered to be *hazardous wastes* under the RCRA.

CERCLA response cost might be forced are on owners and operators of polluting facilities, persons who are both owners of toxic waste and who arranged for its transportion, and, finally, persons who have accepted substances for transportation and/or designated the sites for their transportation.

The federal government is able, under CERCLA, to respond to releases of toxic substances and provide clean up of dump sites. The Act has considerably increased potential liability for anyone who manages hazardous substances. No element of fault must be proven and any legally responsible party can be held liable for cleanup and damage costs under this act.

Waste exchanges that do not take ownership of waste don't appear to be subject to CERCLA liability, yet no specific research has been done regarding the precise meaning of "own or possess" as described within the Act.

Some waste generators have tried to avoid this liability by claiming that their wastes are a product which they will be selling (products for sale are never considered hazardous wastes). These arguments are generally rejected in courts. All RCRA hazardous waste generators are potentially subject to CERCLA liability. Users of wastes who treat or dispose of any portion of it, as well as recyclers of the hazardous waste, must take ownership at some point, and so are also within its power (Industrial Waste Exchanges, 1996, Ch. 7).

APPENDIX D : DEFINING HAZARDOUS WASTE

Hazardous waste listings describe wastes from very specific industrial processes, or wastes in the form of very specific chemical formulations. The EPA has studied and listed as hazardous hundreds of specific industrial waste-streams. These wastes are described or listed on four different lists which are found in the regulations RCRA at Part 261, Subpart D. These four lists are:

• The F list — The F list designates as hazardous particular wastes from certain common industrial or manufacturing processes. Because the processes producing these wastes can occur in different sectors of industry, the F list wastes are known as wastes from nonspecific sources. The F list is codified in the regulations at §261.31.

• The K list — The K list designates as hazardous particular wastestreams from certain specific industries. K list wastes are known as wastes from specific sources. The K list is found at §261.32.

• The P list and the U list — These two lists are similar in that both list as hazardous pure or commercial grade formulations of certain specific unused chemicals. Both the P list and U list are codified in §261.33.

These four lists each designate anywhere from 30 to a few hundred wastestreams as hazardous. Each waste on the lists is assigned a waste code consisting of the letter associated with the list followed by three numbers. For example, the wastes on the F list are assigned the waste codes F001, F002, and so on. These waste codes are an important part of the RCRA regulatory system. Assigning the correct waste code to a waste has important implications for the management standards that apply to the waste.

A chemical may also be defined as hazardous if it is a *characteristic waste,* which is defined as "waste products or materials that have a characteristic such as ignitability, reactivity, corrosiveness, or toxicity presenting significant risk to public and environmental health". (EPA, 1999)

IGNITABILITY

A liquid having flash point of less than 140°F is an ignitable waste. A solid is an ignitable waste if it is capable of causing fire through friction or absorption of moisture, or can undergo spontaneous chemical change resulting in vigorous and persistent burning. A substance which is an ignitable compressed gas or oxidizer is also an ignitable waste.

CORROSIVITY

An aqueous solution which has a pH less than or equal to 2, or greater than or equal to 12.5 is a corrosive waste.

REACTIVITY

A reactive waste is a material that is normally unstable and undergoes violent chemical change without detonating, can react violently with water, or form potentially explosive mixtures, or generate dangerous or possibly lethal gases. A material that is capable of detonation or explosive reaction is a reactive waste.

TOXICITY

A waste that contains one of the constituents in concentrations equal to or greater than threshold limit values designated by the EPA is toxic.

To further delineate chemical waste, two categories pertinent to storage procedures must be defined: halogenated and non-halogenated. Halogenated materials are characterized as organic chemicals containing at least one halogen atom (F, Cl, Br, I) per molecule. Halogenated waste is typically corrosive while non-halogenated waste usually consists of less harmful alcohols and acids. Because of the halogen atoms they contain, halogenated wastes require more energy for destruction than non-halogenated and thus more money.

APPENDIX E: WASTE DISPOSAL SPECIFICS

As found within the examined university programs, waste management is handled by the health and safety departments. These departments oversee the collection of the waste materials on a regular basis (e.g., every week). Collected wastes are transported to the hazardous waste storage facility where the wastes can be safely and efficiently processed. The wastes are then segregated into compatible groups: halogenated , non-halogenated, and Lab Pack. Lab Pack wastes are individual compounds that are incompatible with other groups and are stored and labeled individually. Similar groups (e.g. oxidizers, corrosives, flammables, toxins, and reactives) are combined to reduce packing volume and decrease disposal costs.

Subsequently, an outside contractor is hired to dispose of these wastes, generally through incineration. This process varies in cost due to transportation expenses, as current US incineration plants are located in scattered locations across the continent (e.g., Liverpool, Ohio and El Dorado, Arkansas). The expenses of incineration are approximately $200 for a 55-gal drum of non-halogenated chemical waste, and $400 for a 55-gal drum of halogenated chemical waste (Messier, 11/18/99). As mentioned earlier, halogenated waste requires a higher price because it takes more energy to burn this material. Lab Pack waste costs between $50 and $75/lb for incineration. This is a consequence of the easy combustion of most fine chemicals (Messier, 11/18/99). Waste oil is factored in separately, as it is sometimes recyclable.

At the University of Massachusetts, common dealings are through a consultant who has found a useful recycling option. This option involves the utilization of non-halogenated waste as high BTU fuels. Use of this alternative costs approximately $1.25 per gallon, thus reducing halogenated materials disposal costs by nearly 67%.

Another option exists for non-hazardous chemicals. After being collected and packaged according to legal standards, the material may be sent to a landfill. This disposal option has become less and less common due to environmental worries. In conjunction with these concerns, often the volume of non-hazardous chemicals produced in laboratories is so small that they may simply be flushed down the drain.

APPENDIX F: SURVEYS

APPENDIX F.1: SURVEY METHODS

APPENDIX F.2: SURVEY QUESTIONS

APPENDIX F.3: SURVEY RESULTS

APPENDIX F.1: SURVEY METHODS

There are basic steps for designing surveys. Although not all apply to the small attitude survey conducted for this IQP, the following steps were followed closely.

- Determining if a survey study is the best way to answer your research questions.
- Obtaining a random or representative sample of sufficient size.
- Making an informed choice of survey method.
- Creating a questionnaire that is valid, reliable, and unbiased.
- Designing a questionnaire and implementation plan that achieve a high response rate.
- Developing procedures that ensure that people are treated ethically.
- Conducting a scientifically defensible statistical analysis of the survey data.

Forming the survey appearing in Appendix F.2, open-ended questions were avoided entirely. Rather than supply written answers, the Chemical Waste Management Survey asks attitude questions with a range of answers from one to five.

Questions about personal actions usually give accurate answers. Attitudes are more difficult to measure and cannot be substituted for behaviors for these reasons:

- People are sometimes simply not aware of their true attitudes
- Weakly held attitudes are easily changed
- People tend to respond as if their attitudes are long-held and well-formed even them they were just made up on the spot

Attitudes are very sensitive to minor variations in how questions are worded. As many questions as possible about behaviors were asked and the necessary attitude questions were interpreted with an understanding of their limitations.

Proper wording was especially important for our surveys because of the English-Thai language barrier. Dr. Supawan reviewed the questions prior to their delivery to students.

A professional-looking format is always important for a survey to be taken seriously. The Chemical Waste Management Survey contained no typographical errors and had clear instructions that would not be misinterpreted by students whose first language was not English. Dr. Tirayut explained the reason behind the survey, its relevance to the chemical waste problem in Thailand, and the fact that filling it out was completely optional.

Since people find it easier to answer a survey when its organization is apparent to them, this survey caught the reader's attention with questions pertaining to the central issue of the survey. The five choice answer option was picked because the questions warranted more than two answer choices. Without written answers, translation problems were avoided entirely.

APPENDIX F.2: SURVEY QUESTIONS

Chemical Waste Management Survey
Chulalongkorn University
Undergraduate Students

Background Information:

Anticipated year of graduation: ______________________________

Major area of study at CU: ______________________________

Example:

How would you rate:

x) The amount of homework you receive in your classes 0 1 2 3 4 5

none a lot

By answering 5 you are saying, " I receive a lot of homework in my classes".

By answering 0 you are saying, " I receive no homework in my classes".

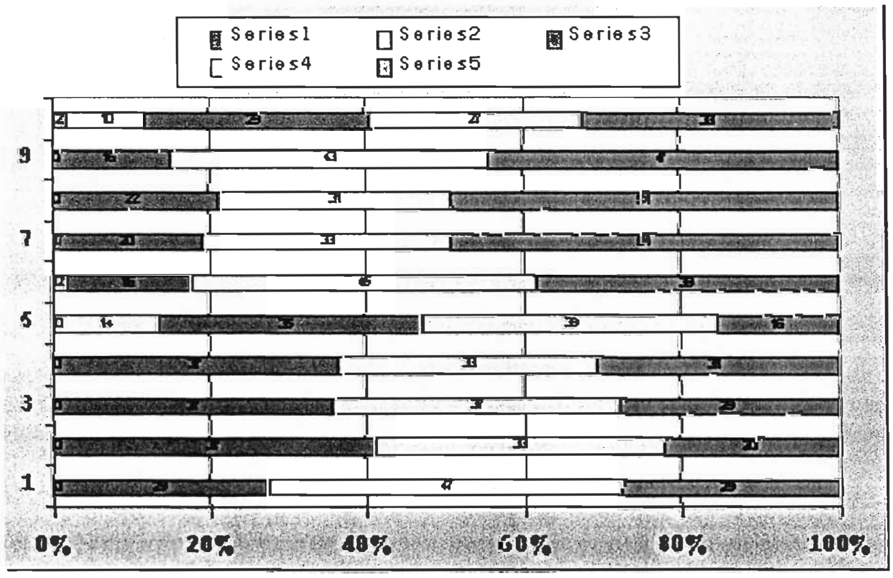
How would you rate:

a)	Your experience with laboratory chemicals	0 1 2 3 4 5
b)	The amount of instruction you have received on the proper disposal of chemical waste	0 1 2 3 4 5
c)	The instruction you have had on laboratory safety	0 1 2 3 4 5
d)	Your awareness of environmental problems in Thailand	0 1 2 3 4 5
e)	The environmental awareness of other CU students	0 1 2 3 4 5
f)	The environmental awareness of CU professors	0 1 2 3 4 5
g)	The importance of proper chemical waste disposal	0 1 2 3 4 5
h)	The importance of reducing chemical waste	0 1 2 3 4 5
i)	Your willingness to change your laboratory practices to be more environmentally friendly	0 1 2 3 4 5
j)	The contribution of chemical waste to pollution problems in Thailand	0 1 2 3 4 5
k)	Have you heard of any chemical recycling on the CU campus?	Yes No

APPENDIX F.3 : SURVEY RESULTS

Question	1	2	3	4	5
Your experience with laboratory chemicals	0	0	29	47	29
The amount of instruction you have received on the proper disposal of chemical waste	0	0	37	33	20
The instruction you have had on laboratory safety	0	0	37	37	29
Your awareness of environmental problems in Thailand	0	0	37	33	31
The environmental awareness of other CU students	0	14	35	39	16
The environmental awareness of CU professors	0	2	16	45	39
The importance of proper chemical waste disposal	0	0	20	33	51
The importance of reducing chemical waste	0	0	22	31	51
Your willingness to change your laboratory practices to be more environmentally friendly	0	0	16	43	47
The contribution of chemical waste to pollution problems in Thailand	2	10	29	27	33
Have you heard of any chemical recycling on the CU campus?	86	14			

Awareness	Yes	No	Same
Professor more than students	27	5	20
Yours more than students	24	6	22
Yours more than professor	11	20	20



APPENDIX G: INTERVIEWS

APPENDIX G.1: INTERVIEW TECHNIQUES

APPENDIX G.2: LIST OF INTERVIEWEES

APPENDIX G.3: STANDARDIZED INTERVIEW QUESTIONS

APPENDIX G.4: SHORT ANSWERS IN STANDARDIZED INTERVIEWS

APPENDIX G.5: INTERVIEW NOTES

Thirayut

Amorn

Varipun

Lursuang

Piyasan Praserthdam

Tharathon Mongkhonsi

Pornpis Silkavute

Mingquan Wichayarangsaridh

Pradit Yongpanchai

Vorapinit Inkarojrit

APPENDIX G.1: INTERVIEW METHODS

There are three types of interviews: standardized, unstandardized and semistandardized. A standardized interview uses a "formally structured schedule of interview questions." The theory behind this method is to offer the same basic stimulus to all the interviewees by asking the questions the same questions in the same order. The assumption in this style is that all the subjects will both comprehend the questions and perceive them in the same way.

An unstandardized interview assumes from the start that the interviewer does not know at the start what the correct questions are. The questions must be determined throughout the interview based on the responses to previous questions. An assumption is also made, which is contrary to one in the previous style, that the subjects will not all perceive a list of predetermined questions in the same way. These types of interviews do require however that the interviewer be fairy adept at deciding on the line of questioning that is appropriate during the interview.

A semistandardized interview is just what the name implies, half way between the standardized and the unstandardized. This method involves using a set of sample questions or topics that need to be discussed and information for which the interviewer is looking. The questions, though are not laid out word for word and the interviewer is allowed the freedom to probe much farther than the original questions. The assumption that is made in this style is that the researcher approaches the world from the subject's perspective. The language and the tone of the questions must be made in such a way that the subject can relate to it.

The interviews that have been conducted so far were conducted in the semistandardized style. The interviews done in the United States were conducted for the purpose of obtaining information. Many of the questions that were asked in these interviews yielded information that prompted more questions. For this reason a standardized interview would have left gaps in the information. However, there were some general topics that needed to be covered and therefore a completely unstandardized interview would also be inadequate.

The interviews that will be conducted in Thailand will also be conducted in the semistandardized style. This style was chosen because similar to the interviews conducted here, those in Thailand will have information that must be covered, thus ruling out a unstandardized interview. In addition, the language barrier will prevent us from making assumptions that are necessary for standardized interviews. The interview process will also require a translator, whose abilities will also have to be taken into account when the interviews are evaluated.

The above information and more detailed information concerning subjects such as question order and content can be found in Berg's Quality Research Methods. The information that we will accumulate in Thailand will come from individuals, such as professors and students.

Date	Name	Position	Email
	Dr. Supawan Tantayanon	Liaison, Professor of Chemistry, Bangkok Project Center Coordinator	supawan.t@chula.ac.th
1/17/00	Thirayut	Professor of Chemistry, Chemistry Department Stockroom Manager	
1/17/00	Thanit Veriyaprom (Tha)	Graduate Student, Chemistry	
1/17/00	Boy	Graduate Student, Environmental Engineering	
1/19/00	Tae	Graduate Student, Chemistry	
1/19/00	Dr. Amorn	Professor of Chemistry,	
1/21/00	Varipun	Professor of Environmental Engineering, ChemTrack Administrator	
1/25/00	Lursuang	Professor, Department of Chemical Technology	
1/25/00	Piyasan Praserthdam	Professor, Department Head, Department of Chemical Engineering	
1/25/00	Kittipong Rattanaporn	Graduate Student, Biochemical Engineering	
1/25/00	Narong Lusksanapivom	Graduate Student, Biochemical Engineering	
1/25/00	Pichanok Nakkharat	Graduate Student, Biochemical Engineering	
1/25/00	Wanwisa Thawisaeng	Graduate Student, Biochemical Engineering	
1/25/00	Waree Iaruwattanayon	Graduate Student, Biochemical Engineering	
1/25/00	Dot Boonyanurak	Graduate Student, Biochemical Engineering	
1/25/00	Komgrit Dalarom	Graduate Student, Biochemical Engineering	
1/25/00	Tharathon Mongkhonsi	Analytical Testing Laboratory, Department of Chemical Engineering	
1/26/00	Pornpis Silkavute	Chief of IPCS Section, Technical Division, Food and Drug Association, Ministry of Public Health	pornpit@health.moph.go.th
1/27/00	Mingquan Wichayarangsaridh	Pollution Control Department, Chief of Hazardous Waste Section, MOSTE	
1/28/00	Dr. Yaron Yoel	GENCO, Chief Operating Officer	
2/1/00	Pradit Yongpanchai	SGS, Division Manager Laboratory Services	
2/3/00	Vorapinit Inkarojrit	GENCO, General Manager	
2/9/00	Wasanon	KMUTT, Professor of Organic Chemistry, Chemistry Department	
2/9/00	Jarurat Voranisarakul	KMUTT, Assistant Professor, Head of Environmental Engineering Dept	
2/9/00	Suchada Chaisawadi	KMUTT, Researcher	
2/9/00	Boosayarat Tomapatanaget	Graduate Student, Chemistry Department	
2/9/00	Praput Thavornyutikan	Graduate Student, Chemistry Department	
2/9/00	Man Phewluangdee	Graduate Student, Chemistry Department	
2/9/00	Miss Orawan Jakdetchai	Graduate Student, Chemistry Department	
2/9/00	Mr. Dachochai Wilairat	Graduate Student, Chemistry Department	
2/9/00	Pakatir Aksharanandana	Professor, Chemistry Department	
	Dr. Vithaya Ruangpornvisuti	Associate Professor, IT Director, Chemistry Department	rvithaya@chula.ac.th

APPENDIX G.3: INTERVIEW QUESTIONS

1) What is your name (in Latin characters)?
2) In which faculty do you currently study/teach?
3) Are you currently doing any research?
4) Are you aware of the negative affects of chemical waste on human health and the environment? What are some of these effects?
5) Are CU professors aware of these effects?
6) Are CU undergraduate students aware these effects?
7) Are CU graduate students aware of these effects?
8) Are there any classes at CU which focus on these effects?
9) Is it important to properly dispose of waste chemicals in the laboratories?
10) Where did you get your undergraduate degree?
11) In what faculty was your undergraduate work?
12) How were chemicals disposed of when you were an undergraduate student?
13) Did you receive instruction on how to dispose of waste chemicals before doing laboratory work?
14) Do undergraduate students at CU follow safe chemical handling procedures (e.g. goggles, lab coats)?
15) Do graduate students at CU follow safe chemical handling procedures (e.g. goggles, lab coats)?
16) Do the chemicals you use for research ever need to be kept confidential?
17) How are waste chemicals disposed of in the teaching and research laboratories at CU?
18) Are there strict guidelines and monitoring of waste chemical disposal in the labs?
19) Do you often witness waste chemicals being disposed of improperly?
20) Have you ever witnessed a serious chemical-related accident in the laboratory? What happened?
21) Do you think people are at risk of injury because of chemical storage or disposal practices at CU?
22) Are there many waste chemicals from laboratories at CU that could be reused?
23) Would you put more effort into recycling or proper disposal of chemicals if more environmentally conscious methods were made available?
24) Is there a need for a solvent recycling program at CU?
25) Would students and professors take part in a surplus chemical exchange if one were set up at CU?

APPENDIX G.4: SHORT ANSWERS IN STANDARDIZED INTERVIEWS

1	Boy	Thanit Ver	Miss Oraw	Mr. Dacho	Pakatir Ak	Dr. Amorn	Group3	Lurswong	Rojrit Roja	Group 1
2	Environme						chemistry	chemical t	Organic ch	Biaochemi
3	No	No			Yes	Yes		computer s	none	yes
4	Yes	Yes	Yes	Yes	Yes	Yes	small amo	yes	yes	yes
5	No		Yes	Yes	Yes	Yes	90%	yes	yes	yes
6	No	No	Yes	Yes	Yes	Yes		yes	yes	yes
7	No	No	Yes	Yes	Yes	Yes				
8	No		Yes	Yes	Yes					
9	Yes	Yes					yes			yes
10	CU	CU	CU	CU	CU	CU	chula	CU	Chula	other schoo
11	Environme	Chemistry					chemistry	chemistry		
12	SAME	same						differently	same	same
13	No		Yes	Yes	Yes		yes	yes	yes	no
14		No	Yes	Yes	Yes	NO	no	Yes	yes	don't know
15	yes	No				NO	no			yes
16	No					no	no	no	no	no
17							divide			
18	No	No	Yes	YES	Yes		sometimes			no
19	Yes						yes		no	no
20	No	No	No	No	No	no	yes	no	yes	
21	Yes					Yes	yes		yes	
22	No	No					no	no	no	yes
23	Yes	Yes				Yes	no	yes	yes	yes
24	Yes						yes/no	yes		yes
25	Yes	DONT KNOW				Yes	yes	yes	hope so	yes

APPENDIX G.5: INTERVIEW NOTES

Interview with Dr. Tirayut January 17, 2000:

The chemical inventory is a new program that has been in existence for only a couple of years. Since its inception, they have been trying to backlog all the chemicals that have been collecting there for 30 years. There are about 2000 Chemicals in stockroom

Previous inventory was a manager who did not keep a written list, he did everything from memory

Stockroom uses an MS Access Application written in Thai. Inventory system was created as an IUCRC project through TIF grants. Chula began 3yrs ago as a pilot study of this program. It is supposed to be used in all faculties dealing with chemicals but some departments still are not using it. It is a very complicated program which has many functions that are not used yet. Currently Dr. Tirayut is testing and evaluating the functions.

A function exists within the program which can link a user to the MSDS (Material Safety Data Sheet) information for most chemicals. The database itself stores data on flammability, toxicity, corrosivity, etc.

The database contains the fields:

Chemical Name (Generally IUPAC however large organics are by common name)

CAS Registry #

Compound Grade

Supplier Name (Most of Thailand uses Merck or Fluka because Sigma/Aldrich has no distribution center nearby; Fluka has a plant in Switzerland)

Catalog #

ChemTrack ID# (individual number assigned by program to each substance delineates between chemical supplier and purity)

Amount in Stockroom

Database can be viewed online at (161.200.32.13/chemtrack) however it has limited degrees of access. Currently, the website is under maintenance, so even fewer features are available. Each department can only view what is in their faculty's stockroom, although there are some people who may be able to access all databases (e.g. the head of the Department of Health). Currently the chemical stockroom manager is the only person able to update the database.

There are three levels of staff at Chula

1st is the professors, Ph. D

2nd is the researcher, has a Bachelors

3rd is other staff.

The stockroom manager, which is not an official position is the 2nd. Dr. Tirayut is overseeing the project and is, of course, the 1st level.

Stockroom person should immediately update database if a chemical leaves the stockroom, however, this is not always the case. Stockcards are always updated immediately. There are frequent problems with the network connection at Chem 1 and Chem 3. They would like to have a more concrete system in place where stockcards are gathered and the system is updated once a week.

Since the program is currently in its testing phase and Chula currently uses both the stock card system and the electronic database. This acts as a safety net in case anything should go wrong. They want to use stock card and then update the database when they have time.

At the present stage, for the sake of simplicity, the system planned requires that the user take the entire container of chemical. Once a chemical leaves the stockroom, it is removed from the stock list, and no further tracking is done on it.

When chemicals are returned in open bottles, they become second-class chemicals. These 2nd class chemicals are more readily used by researchers because these chemicals are free. Teaching labs usually demand first class chemicals because they get them for free anyway.

There is no current function within this program to automatically notify the manager about a chemical's shelf life expiring, or nearing expiration

Dr. Amorne, 19 January 2000,

New Science Center:

There are 2000 undergraduate chemistry students. Right now it is difficult to accommodate everyone. They were going to build a new 10 story building just for chemistry and give up the ones already in existence but the new science center was being built and administration said that the only way to get new space would be to get into the new science center. Therefore chemistry has taken floors 7-15 in the new building. Undergrad teaching labs are on floors 7-10.

There are two systems currently designed for waste water treatment, one for chemically polluted wastewater and one for human wastes.

There are also two systems designed for air safety. General chemistry and organic chemistry have been split into two sections. There are 275 fume hoods for the two combined however, for in-organics the fumes will go through water scrubbers and then be directed straight outside where they will be monitored so that harmful chemicals are not let off into the atmosphere. The organics fume hoods are separated from these vents, their air is cleaned through the same process then directed through fans on the roof of the building. These safety precautions were taken especially because all of the rooms in the new building are air conditioned and there is a danger of harmful fumes re-entering the building through these units.

The Chem 1 building which now consists of classrooms, laboratories and the current chemistry stockroom will be transformed into a chemical stockroom for the entire campus.

Fire and safety training will also be held in chem. 1 to occupy the rest of the space so that it is not taken away.

Chem 2 or Chem 3 is intended to become a safety training building.

Safety and Disposal:

Currently safety standards are not what they should be at CU, especially among undergraduates. The don't wear lab coats, goggles, protective gloves, etc. This is intended to be changed upon moving into the new building. Labs will be more carefully monitored and students practices will be more seriously regulated.

Disposal is known to be a problem but no one has initiated a change so professors don't worry about it. Currently wastes that are not flushed down the drain are combined in a steel drum and stored in the rear parking lot of the Chem 1 building. A better method will be decided upon when department moves into new building.

Currently a water treatment plant is being built in Bangkok, it has been in the process of being built for 5 yrs. Should take care of chemical polluted water.

CU would greatly benefit from having it's own incinerator.

Right now, hexane, chloroform, and some mixed solvents are recycled.

Chemical Inventory:

Merck must get rid of all chemicals that have been sitting around for five years. These chemicals are given to CU free of charge.

Dr. Amorne used to keep up own inventory, after a while stock became so large list became obsolete.

Recently a Professor in the Faculty of Accounting worked together with an American company called Oracle to build a software package for the entire university which automatically does accounting and inventory. The university bought it for $500,000.

Financial details:

If a person receives money from the school, a portion of that is put aside for any chemicals or other inventory they might need. Grants for graduate students or researchers might be setup to be kept in separate accounts. The department manager would oversee these accounts. They may order through this system if they have an account within the finance department. Otherwise they must put the amount they are spending into their departments account and order through that.

Demonstration of how program runs:

Person needs an item, fills out form and sends.

Form is received by accounting to make sure enough money is in the budget

Form is received by inventory in case material is already on campus

If so, material is picked up by requestor.

If not, form goes top purchasing who finds lowest price.

Form is then sent to supplier, supplier sends out goods.

When material is brought to campus, money is withdrawn from recipient's account.

This program, like others has limited access. The requestor may view the progress of his or her order. Accounting may only see accounting, inventory may only see inventory.

There is no viewable inventory database that is open for all to see.

This program is meant to do all accounting for campus and is expected to make ChemTrack obsolete.

Chemical Exchange:

Dr. Amorne suggests a bi-lateral program which runs off of a credit/debit system. If such a program could be set-up, new program might be perfect. Worries that people will donate little and take a lot of chemicals.

Threw away 1/3 of chemicals in inventory because of no labels or faded labels.

Sometimes graduate students trade chemicals as an informal exchange

Interview with Varipun, 21st January 2000

Environmental steps must be taken in chemistry because of past accidents such as a Gas Truck explosion and an explosion of $KICO_3$

In Thailand there are 1.5 million tons of hazardous waste, and 1.2 million are produced by industry.

IUCRC-EHWM

Phase I- pilot for waste management
Phase II- provincial and industrial WMP
Phase III- Regional WMP
    5 universities were funded, each had 2 years to set up models

There were 4 systems developed
- GPS/GIS
- Chemicals management
- Lab waste management
- Emergency response program

Software: CHEMTRAC (1st year operation)

There is a tracking system which is both for administration and safety

The current database has 7000 chemicals. Originally there was some information and since then it has been expanded to include 10 fields.

Interview with Dr. Lursuang, 25th January, 2000:

Chemical Technology CHEMTRACK manager

The chemical technology department only purchases a chemical when a student or professor requests it.

There are about 100 chemicals used in teaching labs in this department and the labs use the same chemicals each year, and thus all the chemicals that are leftover for an exchange are from previous research. They receive the chemicals that they order in two or three days.

He figures that other departments have about the same waiting period.

All received chemicals are logged onto stockcards and then transferred onto the database.

There is a list of chemicals (which he has provided) that have not been used in years, and they are located in the stockroom. It would be easy to keep and update this list often.

If people wanted to use chemicals from another department, it should be free to use them, but permission should be asked first. No one has ever asked for these chemicals before.

CHEMTRACK SOFTWARE: A web page (in Thai) that has a list of the departments and a space to search for the name of the chemical. The department must be selected separately and so only one can be searched at a time. This is not a huge hassle at the moment though because there are only seven departments listed.

Dr Lursuang and his storeroom manger have access to the database for this department but of course they can't access the other databases. To find a chemical would have to contact a department to get a chemical from them.

When a chemical comes into the storeroom, it is put into the inventory. When a professor comes to pick it up, they must fill out a form saying that they have taken it. However the database is never updated to say that the chemical is no longer in the stockroom. Thus the inventory is really a list of all the chemicals that have passed through the stockroom.

Dr Lursuang believes that the fields that are currently presented in the CHEMTRACK software would be all that is necessary to choose a chemical from a waste exchange.

Waste from the department currently goes one of two routes, some is "diluted" and the rest is burned.

They regenerate solvents now that are used a lot such as Carbon Tetrachloride.

There is often a two to three day turn around between when chemicals are ordered and when they arrive.

There are seven departments, only in the department of science. The faculty of engineering isn't participating.

Petrochemical College is for graduate work only.

ChemTrack is tedious because you must have a chemical catalog on hand to reference the exact chemical you want.

Chemical Technology:

In this department, chemicals are only purchased when they are requested by a student.

The teaching laboratories use the same chemicals each year.
There are about 100 different chemicals
It takes about two or three days for a chemical to be ordered.
These are all entered into ChemTrack
Both stockcards and the database are updated

We have a list of chemicals that are in the storeroom that are never used. Such chemicals are never disposed of but are usually kept.

The stockroom in this department is used for both teaching and research.

It would be very easy to create a list of chemicals that are not being used on a regular basis.

In a chemical exchange, these chemicals can be given away without charge, but the user should ask permission first. No one has ever asked for these chemicals before.

ChemTrack software:

Displays a page that displays a searchable database for each department that is currently using such a system. As the administrator of the chemical technology database, he can access this and change the information on it. The information that is on the other databases can be searched by name, number and other things.

The waste in the chemical technology department does two things with its chemical waste. Some of it can be burned and some of it is diluted.

Some solvents such as tetrachloride are regenerated

Dr Piyasan Praserthdam, 25th January, 2000:

Not using ChemTrack, never heard of it

He does not teach undergraduates

If one is doing research here, one simply buys the chemicals that are needed.

The engineering department has eleven laboratories and abut 30 staff.

He believes that the stocks should be check frequently, especially for common and expensive chemicals ???

Chemicals that are not going to be used anymore can be given away for free.

Other chemicals that are used frequently might be used again, and the department might want to charge for them.

There is also a time consideration of chemical delivery here in Thailand. The time between an order and delivery can be from three weeks to two months. This is the main problem with doing research in Thailand.

So a "borrow" system might be set up in which a chemical that one department has might lend it to someone else until the other party gets their substance delivered upon when it can be returned. Chemicals could be listed in three categories:

Free
Borrow
Charge

There is a concern about confidentiality but this should not stop someone from listing their chemicals. If one wants to know the chemicals that are being used in the research of another. One can simply ask the staff and graduate students that are involved and will probably get the information, so this exchange would not reveal anything.

Most of the research comes from the government. This means that reports are due and viewable by anyone, so there are few secrets. It is important to keep secrets in the beginning of one's research because it may take many years to complete some research.

An inventory would benefit the research group but who would do it??

Tharathon Mongkhonsi, 25th January, 2000:

Burn organic chemicals. Don't burn carbon tetrachloride- keeps it in bottles

Acid and base are kept until the end of the term when it is neutralized.

Normally their chemicals are in gas phase.

Confidentiality is not a problem.

Are professors aware of the importance of waste disposal?

"If you ask, they are. If you watch, they aren't"

He isn't sure if the students are aware. Problem: sometimes when the professors tell them things, they are joking, but other times they are serious

No wastewater treatment system.

Accidents in lab: serious fire with ether. Student didn't want to be a Chem Eng afterward.

3 staff for 20 students

students usually want to finish as quickly as possible.

They have a safety class at the beginning of the term and a lecture before each lab on safety.

There are no written instructions on waste disposal.

Undergraduates don't deal with gases- just graduates.

"Very important to dispose of chemicals properly. To find someone to follow the procedures is difficult."

"Sometimes situation is not dangerous and they are afraid. Sometimes it is dangerous and they don't care."

Storage is safe in Analytical lab. Keeps things that react apart.

He would put effort into better disposal methods if they were practical.

The lab is moving back to the old building. Problem is that the fumes from high temperature burning of wastes are toxic and the building is low. Fumes go out of ventilation and into new science building. Current building was not designed to have the analytical lab.

He thinks lots of chemicals are wasted.

The dean or president doesn't like to punish, so it is difficult to enforce rules.

People have asked to borrow chemicals. Sometimes they give them. Say no if they ask for too much. The analytical lab never asks for chemicals.

"they don't have a stockroom, so the room looks like a stockroom."

"if someone wants the chemicals, they can have them for free." There are 250-300 they could offer.

Pornpis Silkavute 26th of January 2000

Ministry of Public health

Khun Pornpis is the secretary general of the Food and Medicine Department, which is similar to the US FDA, dealing with food, drugs, and cosmetics. She is also involved in the National Committee on Chemical Safety.

Food and Medicine Department's main aims:

-Protect Consumer

-Ensure safe products with good quality

Responsible for Safety Scheme:

-Food Safety
-Chemical Safety
-Drug Safety

The IPCS-

There is a National Committee for Chemical Safety which runs the Internal Program for Chemical Safety (IPCS). IPSC is supported by the UN (united nations), WHO (world health organization), ILO (??). It was created 10yrs ago to protect people and the environment. They do safety assessments to minimize affects of chemicals on the environment. Thailand became a member in 1985 with 30 high ranking government officials from some agencies.

The Chemical Safety Section of the food and drug administration of Thailand is also involved in this program. Their main job is to protect the consumer. Their meetings are attended by representatives of other organizations such as NGO's, the Min of Sci, Tech and the Env, and the private sector.

1994: Intergovernmental Forum on Chemical Safety (IFCS) by IPCS

There are three sections of this organization; Informational Support, Support for Environmental Protection, and Clinical Toxicology.

The IPSC has several functions,
Policy and planning which is in charge of
Assessment
Establishment of network of poison control offices
Establishment of public promotion of chemical safety
- Support Function
  - Coordinating
  - Full center for information
  - Poison information center
  - Database for use in Thailand
- Control Function
  - Laws governing industrial sectors
  - Cradle to grave control

The 1st national master plan was developed in 1995 a the 2nd national master plan is currently being developed to account for the socio-economic structure of the country and will deal with universities (?).

Who should address universities? Ministry of Industry, not MOSTE

How to get funding for the waste exchange:
propose to MOI, MOSTE and ask for budget
"Maybe enforcement will be enforced in the second plan"
Government system is too big.
Hospital waste controlled by Min. of Pub. Health
See Nat. Chem. Mgmt. Prof. Pg. 19. Come to MOSTE with information on how much waste in university

Supawan: "how we get rid of waste is not concern. How we reuse waste is concern."

Education: pg. 97 of Master Plan

Schools:

Elementary: (Supawan did this and it worked.)

-show how chemicals work

-learn about chem.. and how to be safe

PCD, the pollution control department is under MOSTE, the ministry of science technology and the environment

This covers the pollution control act and the hazardous waste control act

Meetings for Master Plan:

-Anyone invited

-NGOs and businesses come

-2 or 3 NGOs at least are members of subcommittees.

-National Seminar 1 time per year.

NGOs in Thailand are still weak.

She wants to see more cooperation between NGOs, business, and gov't

Regulations and Enforcement-

There was a policy analysis done to understand the strengths and weaknesses of the 1st master plan.

The government structure is too large for efficient administration of the rules.

The pollution control in Thailand is governed under the 1st master plan by several organizations pertaining to its source. Industrial pollution is covered by the Ministry of Industry. If the waste is produced by agriculture processes, the Ministry of agriculture governs. Hospital waste is controlled by the Ministry of Public Health. The pollution control department under MOSTE handles complaints by people and runs campaigns for public environmental education

There are no current regulations for Universities under the 1st plan. The second might strengthen enforcement. If there was to be rules, it should be proposed by the Ministry of Public Health and then developed by the Ministry of Industry or Education.

Mingquan Wichayarangsaridh, 27th January, 2000:

<u>Pollution Control Department</u>

The Pollution Control Department is under MOSTE

Its role is to

1)

2) set standards for air and water waste management

It deals with air pollution, water pollution, and hazardous waste.

It has a technical office to support other offices.

There are 6 divisions of the PCD
    Air Pollution
    Waste water
    Solid waste

Many projects involve hazardous waste, the PCD provides information to the public and make regulations

Hazardous waste control is divided by the Ministry of Agriculture, and the ministry of industry and the ministry of public Health.

There are ideas for an information exchange center for chemical waste and waste management, but there is no progress yet.

There is currently recycling in Thailand. There is plastic recycling, glass recycling and organic materials. It is estimated that 30-40% of the materials used her could be recycled, and the actual number has risen in the past few years from 10 to 15%

There is a project to get industry to do this and the PCD is supporting the ministry of industry.

There is currently "end of the pipe" control in which the substances that are released are treated or disposed of, but this needs to change to a focus on the source of the pollution.

There is a lack of enforcement: There are not enough inspectors and the penalties for breaking the laws are not bad enough to warrant not having dispose of them. It is cheaper for businesses to break the law than to follow regulations. If a company breaks the law, the police are responsible

To create penalties, the government would have to revise the National ____ Promotions act. This is very difficult and would take a great deal of time. But there are enough laws now, they just need enforcement.

PCD has jurisdiction if:
    Complaints are received
    Things are discussed with other ministries
    They sue an industry
    EGAT (electricity generating authority of Thailand) ????

There are no University standards. The PCD is currently studying hazardous waste in laboratories and has sent information to the CU president.

The university should act as a leader...

the government sector takes care of itself. Sometime the PCD goes to other government sectors, finds problems, and sues them.

There is an emphasis on a central facility that would handle
    Separation
    Treatment
    Disposal

This should be handled by private sector

Thai people believe in foreign expertise

-Study was done by US firm

Existing exchanges:

Information exchange center

Materials exchange for recyclables

-sell production, clean, virgin wastes from industry

-contact directly- no online system. Sometimes companies come to them to ask where they can get rid of waste.

-Materials exchange is handled by the Waste Minimization Section of the Hazardous Waste Management Division

PCD:

-Promotes private sector to use recycle plastics

-Rewards companies that use recycled plastics

-Provides collection trucks

-will soon have a tax for packaging

-educates the public

-provides 4 different bins:

yellow

green

blue

gray

Pradit Yongpanchai, 1st February 2000:

SGS

Surplus chemicals that this exchange will focus on probably occur more in research labs than in this sort of company.

SGS is not a research company and has no research lab. It is a company that does routine chemical testing of products for quality control, which fits into several categories toys, chemical biological, agricultural, mineral, environmental ands consumer goods. They also certify shipments.

As a business the policy in the company has become to only accept continuing, long term, and multiple customer jobs. Tests and processes that can be done for many companies are more profitable. Single customer and one time tests are not done. This is because it takes a time, chemicals, equipment and expertise to setup a testing process. One time tests also leave many leftover chemicals. Most of the testing that is done is to comply with standards such as ISO 9000 and IS0 14000. SGS serves about 30 companies.

SGS is a national and international certifier of ISO and part of the National Accreditation Council.

A company looking for a national certification looks for a local Thai company because it wants a certifier that is more relaxed.

This means that SGS buys most of its chemicals in bulk. Its inventory system tracks how much of a chemical is left and automatically orders it when the chemical drops below a predefined amount.

Surplus chemicals may occur sometimes if the standards change and a testing process becomes outdated.

The products from the test reactions becomes waste. Of this there is very little reusable waste. The cost of recycling is high and so the supplier of the chemicals at SGS are taken back by the company who supplies them. It is not known what that company does with the wastes.

"people and government are not concerned or enforce environmental issues"

There are regulations in Thailand, but there are problems with implementation.

There are sometimes time problems when procuring chemicals for these reactions. Jobs are sometimes subcontracted to other companies. 90%-100% of the chemicals used are imported. While some supply companies do have stations in Thailand most chemicals are either understocked or not stocked at all.

Really big jobs are subcontracted overseas because there is too much investment for a Thai company to make.

Surplus chemicals are probably abundant in government research labs. The government has a budget which it must spend. Thus it orders chemicals hat it may or may not need in the future.

Vorapinit Inkarojrit, 3rd February 2000:

GENCO

Present:

Vorapinit received his environmental degree at imperial college in London and then spent 5 years in Scotland offshore drilling.

GENCO formed in 1994 and 28% stockholder is MOI

GENCO manifests the wastes it treats

Currently GENCO operates two plants that dispose of chemicals

- Samaedom- in Bangkok
  - Built by MOI as demonstration plant in 1988
  - 100,000 tons
  - Mainly electronics wastewater containing heavy metals, alkalines, acids
  - They precipitate the heavy metals
- Mataput- in Rayong
  - 100,000 tons

Designed by Waste Mgmt Int. (WMX)

Both handle organic and inorganic wastes

Has a US$4 million lab for analyzing wastes

Main treatments:

Stabilization:

Haz and non-haz inorganic wastes

Heavy metal sludges

All treatment done on site at Mataput

Fuel Blending:

Sell to concrete manufacturers for a low price

Organic wastes

Mix at Mataput

Almost all of the waste management that is done in Thailand is governed by a 1986 report by a Thai company. This resort categorized the waste in Thailand into 7 streams:

Waste

Solvent

Organic

Wastewater

Photographic

There were 1.6 million tons of hazardous waste being generated in 1986. Now estimated at 2.2 million.

There are 200 million tons of waste created in Thailand each year, GENCO treats 200,000 tons of waste and is the only disposal company in Thailand. Severely limited hazardous waste treatment facilities in Thailand have resulted in 1/10 to 1/20 of waste generated in Thailand being treated (GENCO flier).

The government plan mentions that recycling and exchange is possible but doesn't mention how, it is a vague regulation

GENCO does Fuel Blending, and stabilization and solidification.

Fuel Blending is when organic wastes are blended and then burned in a cement

kiln incinerator. There is a 4,000,000 USD lab to analyze these waste to be assured that they are all organic.

Stabilization is when an acid or base is neutralized and then diluted

Solidification is when the heavy metals are precipitated out and then placed in a

concrete box and put into a landfill

When asked if there was any waste that they deal with that could be recycled, he replied that there is not enough research done in this area. They are unaware of what these wastes might be used for. The GENCO labs do have the ability to analyze a substance though.

GENCO does not have a minimum quantity to treat, nor a minimum price that must be paid. One can have 200g treated if necessary. However this will not be economic because the transportation costs are the same for the first coupe tons. This is because the transportation must be according to the laws as well and so an authorized truck must pick it up. GENCO is also the only company with drivers that have transportation licenses to carry these materials in Thailand.

The general procedure for a normal company with waste is that a consultant comes and takes a sample of the waste. This is given a TCLP test to identify the minimum quantity of that waste must be treated. With this value, GENCO can give a price. (???)

The stabilized material must pass a leeching test (TCLP) and a test of compressive strength of the concrete block.

See page 30, section 1.8 of the little white booklet

GENCO has approximately 6,000 customers (separate factories) mostly in 22 industrial estates

GENCO cannot take:
- Explosive (military disposes of them)
- Radioactive (must go overseas to be disposed of 3 km deep)
- Highly reactive wastes

Mercury and cadmium are the worst wastes.

Supawan:
- Is there a budget for disposing lab chemicals at CU? No.

Wastewater treatment in Thailand:
- 3 or 4 municipal facilities
- No capability for chem. Waste
- Ministry of the Interior
- Bangkok Metropolitan Agency
  - Cleaning Department
    - Municipal wastewater
    - Solid waste

Funding for GENCO
- No government funding
- Board of Investment (BOI)
  - Gives GENCO some breaks because they want to encourage investment
- Part of an environmental fund

GENCO joined with BMT
- Mercury contaminated wastewater and sludge from oil and gas drilling

Future:

GENCO is only in the first stage of its long term plan. Its stabilization, secured landfill, and fuel blending methods have the potential to treat 65% of the hazardous waste in Thailand, but only 14% is being captured now. The remaining 35% of waste untreatable by these methods can be addressed with chemical treatment and incineration in the second and third stages of GENCO's plan. There will be two incinerators for GENCO to make use of within 2 years. One is being built by the IEAT at the Bangpoo Industrial Estate and the other is being built by MOI (GENCO flier).

By 2001, it is estimated that 2.8 million tons of hazardous waste will be generated in Thailand by industry each year. In 1986, this figure was only 0.53-1.12 million tons per year (GENCO flier). Most of this waste is created by industry, but GENCO recognizes that universities such as CU are also a source. They picked up wastes from the Faculty of Physics once in the past. Since lab-packing has become a new venture of GENCO, chemical wastes such as those stored behind Chemistry 1 could be taken by GENCO for disposal at a cost of 5,000 to 10,000 baht per ton. The least expensive route, according to Vorapinit, would be to collect chemical wastes from the entire IUCRC and separate them by category. A further suggestion was for CU to setup a committee to organize waste disposal for the entire campus.

In the past, GENCO has taken fluorescent tubes and batteries from government agencies, free of charge. When asked about their interest in establishing a partnership with the CU chemical exchange, Vorapinit stated that GENCO was unlikely to donate their services, since they are a for-profit company. He was enthusiastic, however, about a proposal to publicize the exchange during consultations when eligible chemicals for the exchange were identified at industrial sites.

Surak Sujaritputangoon, Saturday 19 February 2000:

HJE Manager
HMC Polymers Co., Ltd.
Surak@hmc.co.th

Polypropylene manufactures part of a bigger international company called Montell. Started out as a domestic company but now sell polypropylene to 40 countries. Over 50% of their volume is international.

The company buys propylene and uses a manufacturing process to change it into polypropylene. It sells product in many forms to many different buyers. HMC has three suppliers of propylene: NPC, a company that makes it from propane which is separated from the gas destined for the powerplant in Mataput. RPC which refines propane and ROC.

They produce 360 metric tons/ year of polypropylene

HMC has application research. Montell does technology research headed by the "technology team". The application research is the business end that finds new customers and products that they might need. Once these products are decided upon, the technology team is given the task of creating the product.

They can not change the actual formula of the substance because it is patented but they can change the product formulation.

They do have research chemicals for this purpose that use chemicals. Chemical labs, physical labs, gas labs and product application labs

When a new product is created, a testing process must be found to analyze the additives. For this they have to do an educated trial and error approach to find the best chemical for this testing. So chemicals that are purchased to try, are not used again if a better chemical is suited for the job. With experience they only have to try 2 or 3, not 20. Years ago they had to try more. Some chemicals are purchased and never used at all.

Last year they donated a large number of these leftover chemicals to Chula. Donated 70 of leftover chemicals. He is not sure if they would sell or give chemicals to other companies. Most of their chemicals were in their original bottles and some were never opened.

They would be willing to take chemicals from other companies

There are more than 50 plants in Mataput

"50% of the companies [in Mataput] have been waiting for this project"

"Chemicals are kept on the shelf for a long time and there is no for disposal companies to deal with many [large numbers of small amounts of] chemicals"

Specific chemicals for research can take 2 or 3 months or sometimes a supplier can not get it at all. Zylene and other commonly used chemicals at the factory will take about 7 days. Rush order will deliver in 1 day. It would be helpful to have an exchange to get chemicals faster than ordering them for special chemicals.

"There are many companies like this."

MSA- Mataput Safety Association is an organization which all the factories in Mataput are members of. They have to pay a member fee. The association has two employees and an office. Sometimes at the monthly meeting one company will say that they have a leftover chemical and another company will need it, and there will be a little exchange. HMS was successful in exchanging some Nitric Acid a few years ago. However this organization did not have strong management and the exchanging disappeared when they lost management. The exchange would advertise at the meetings. He thinks that the Bangpoo industrial park has a similar program.

It has a 5,000 baht/year membership fee. No staff to create a publication

The MSA mostly handles public relations for the industrial park with the community. They handle events such as firefighting days at the schools and sometimes training courses to members.

Sometimes they have to return a chemicals and pay the supplier to dispose of it. They did this with 5 cylinders of Chlorine gas, 20,000 Baht

They showed the list of chemicals that they had from their research lab to GENCO who said that they could not dispose of them because there couldn't do so many little ones. The chemicals couldn't be combined, they would react. However GENCO does take most of their production waste. Their manufacturing process does not really create waste, but the machines must be purged and the lube oil becomes waste

They do sell the bad polypropylene that is produced while the machines are being cleaned out to buyers that use it for low quality products

There are MOI regulations implemented under the factory act in 1998 and there is a big fine if they dispose of their waste wrong. Also because they are multinational company, they want to be ISO14001 certified which means disposing of waste properly and keeping an inventory of all chemicals.

In addition to extra lab chemicals they have production chemicals that have expired. These can not be put into the product and so they are either sold to scrap customers or sent to GENCO.

They would be very interested in Donating because they had success with Chula last year. Other factories are probably the same. He thinks that they have been waiting for our project. Some labs have been accumulating chemicals for 10 years. Some chemicals were not yet expired.

They do have internet access, but he can't say that everyone in Mataput does. There are others though. He thinks that we should go to the MSA meeting to present our exchange.

There are informal exchanges between some of the factories, but they are usually a borrow situation based more on time or budget restraints. No one ever forgets to return the chemical. All of the lab managers know each other in the 4 HMS plants and so this is common. These chemicals are usually in their original bottles, sometimes they are even unopened.

There are not really any byproducts with the process that HMS is into, but some other factories do use their byproducts for making other things, such as candles. Hexane can be used as a cleaning reagent and Zylene as a fuel.

Byproducts can not be used in the lab because they always use reagent grade. They have never used commercial or industrial grade.

HMC doesn't generate much waste compared to other companies

Most companies in Mataput use GENCO because of the Factory Act

The motivations are disposal costs, space, safety, and the concern of the disposal companies ability to handle the chemicals properly.

Motivations:
Cost
sell
donate
dispose
Safety
Storage Area
Disposal does not perform well

They would like to sell the chemicals, if not donate them. If not keep them. This is where the space and safety come in, and if those are a problem then they would pay to dispose of them.

Meeting with MSA

1-4 PM on Feb. 24 at ARC

APPENDIX H: WEB PAGE ASP SCRIPTS

CONTRIBUTE.ASP

```
<html>
<SCRIPT LANGUAGE=VBScript RUNAT=Server>
FUNCTION CheckString (s)
			If isnumeric(s) = 0 Then
			pos = InStr(s, "'")
			While pos > 0
				s = Mid(s, 1, pos) & "'" & Mid(s, pos + 1)
				pos = InStr(pos + 2, s, "'")
			Wend
			CheckString="'" & s & "'"
		Else
			CheckString = s
		End If
END FUNCTION


</script>

<%
			Set Conn = Server.CreateObject("ADODB.Connection")
			Conn.Open "SCECU"

			Set RS = Conn.Execute("SELECT * FROM tbl_remove")
			Count4 = RS.Fields.Count-4
			Count3 = RS.Fields.Count-3

emptyform = "yes"
			first = "yes"
			sql = "INSERT INTO tbl_contribute ( "
			For IntLoop = 0 To Count4
				if first <> "yes" then
					If Request.Form(""&RS(IntLoop).Name&"") <> "" Then
						sql = sql & ", " & RS(IntLoop).Name
					End If
				else If Request.Form(""&RS(IntLoop).Name&"") <> "" Then
					sql = sql & RS(IntLoop).Name
					first = "no"
					emptyform = "no"
				End If
				End If
			Next
			If emptyform <> "yes" Then

			If Request.Form(""&RS(Count3).Name&"") <> "" Then
				sql = sql & ", " & RS(Count3).Name
			End If
```

```
		sql = sql & ") VALUES ( "
		first = "yes"
		For IntLoop = 0 To Count4
			if first <> "yes" then
				If Request.Form(""&RS(IntLoop).Name&"") <> "" Then
					sql = sql & ", " &
CheckString(Request.Form(""&RS(IntLoop).Name&""))
				End If
			Else If Request.Form(""&RS(Intloop).Name&"") <> "" Then
				sql = sql & CheckString(Request.Form(""&RS(Intloop).Name&""))
				first = "no"
			End If
			End If
		Next
		If Request.Form(""&RS(Count3).Name&"") <> "" Then
			sql = sql & ", " & CheckString(Request.Form(""&RS(Count3).Name&""))
		End If
		sql = sql & " )"
		Set Conn = Server.CreateObject("ADODB.Connection")
		Conn.Open "SCECU"
		'Response.write sql
		Conn.Execute(sql)
		Conn.Close

		Message = "Thank you taking part in the Surplus Chemical Exchange at Chulalongkorn
University."
		Else
			Message = "Please fill in the contents of the contribute form."
		End If
%>

<html>
<head>
<meta http-equiv=Content-Type content="text/html; charset=windows-1252">
<link rel=Edit-Time-Data href="./contribute2_files/editdata.mso">
<style><!--
.Normal
	{font-size:12.0pt;
	font-family:"Times New Roman";}
-->
</style>
</head>
<body lang=EN-US class="Normal">
<FORM ACTION="contribute.asp" METHOD=POST>
  <table border=0 cellpadding=0>
    <tr>
      <td colspan="3" valign=top class="Normal" height="77"
    ><!--#include virtual="/scripts/SCECU/include/Title.inc"--></td>
    </tr>
    <tr>
      <td rowspan="3" valign=top class="Normal" height="231" width=153 align="left"
    ><!--#include virtual="/scripts/SCECU/include/NavBar.inc"--></td>
      <td colspan=2 valign=top class="Normal"
    >
        <h1 align=center style="TEXT-ALIGN: center"><font color="#0000CC">Thank you taking part in
the Surplus Chemical Exchange at Chulalongkorn University.</font></h1>
      </td>
    </tr>
  </table>
 </form>
```

```
</body>
</html>
```

REMOVE.ASP

```
<html>
<SCRIPT LANGUAGE=VBScript RUNAT=Server>
FUNCTION CheckString (s)
			If isnumeric(s) = 0 Then
			pos = InStr(s, "'")
			While pos > 0
				s = Mid(s, 1, pos) & "'" & Mid(s, pos + 1)
				pos = InStr(pos + 2, s, "'")
			Wend
			CheckString="'" & s & "'"
		Else
			CheckString = s
		End If
END FUNCTION


</script>

<%
			Set Conn = Server.CreateObject("ADODB.Connection")
			Conn.Open "SCECU"

			Set RS = Conn.Execute("SELECT * FROM tbl_remove")
			Count4 = RS.Fields.Count-4
			Count3 = RS.Fields.Count-3

emptyform = "yes"
			first = "yes"
			sql = "INSERT INTO tbl_contribute ( "
			For IntLoop = 0 To Count4
				if first <> "yes" then
					If Request.Form(""&RS(IntLoop).Name&"") <> "" Then
						sql = sql & ", " & RS(IntLoop).Name
					End If
				else If Request.Form(""&RS(IntLoop).Name&"") <> "" Then
					sql = sql & RS(IntLoop).Name
					first = "no"
					emptyform = "no"
				End If
				End If
			Next
			If emptyform <> "yes" Then

			If Request.Form(""&RS(Count3).Name&"") <> "" Then
				sql = sql & ", " & RS(Count3).Name
			End If
```

```
		sql = sql & ") VALUES ( "
		first = "yes"
		For IntLoop = 0 To Count4
			if first <> "yes" then
				If Request.Form(""&RS(IntLoop).Name&"") <> "" Then
					sql = sql & ", " &
CheckString(Request.Form(""&RS(IntLoop).Name&""))
				End If
			Else If Request.Form(""&RS(Intloop).Name&"") <> "" Then
				sql = sql & CheckString(Request.Form(""&RS(Intloop).Name&""))
				first = "no"
			End If
			End If
		Next
		If Request.Form(""&RS(Count3).Name&"") <> "" Then
			sql = sql & ", " & CheckString(Request.Form(""&RS(Count3).Name&""))
		End If
		sql = sql & " )"
		Set Conn = Server.CreateObject("ADODB.Connection")
		Conn.Open "SCECU"
		'Response.write sql
		Conn.Execute(sql)
		Conn.Close

		Message = "Thank you taking part in the Surplus Chemical Exchange at Chulalongkorn
University."
		Else
			Message = "Please fill in the contents of the contribute form."
		End If
%>

<html>
<head>
<meta http-equiv=Content-Type content="text/html; charset=windows-1252">
<link rel=Edit-Time-Data href="./contribute2_files/editdata.mso">
<style><!--
.Normal
	{font-size:12.0pt;
	font-family:"Times New Roman";}
-->
</style>
</head>
<body lang=EN-US class="Normal">
<FORM ACTION="contribute.asp" METHOD=POST>
  <table border=0 cellpadding=0>
   <tr>
    <td colspan="3" valign=top class="Normal" height="77"
   ><!--#include virtual="/scripts/SCECU/include/Title.inc"--></td>
   </tr>
   <tr>
    <td rowspan="3" valign=top class="Normal" height="231" width=153 align="left"
   ><!--#include virtual="/scripts/SCECU/include/NavBar.inc"--></td>
    <td colspan=2 valign=top class="Normal"
   >
      <h1 align=center style="TEXT-ALIGN: center"><font color="#0000CC">Thank you taking part in
the Surplus Chemical Exchange at Chulalongkorn University.</font></h1>
    </td>
   </tr>
  </table>
```

```
</form>
</body>
</html>
```

LIST.ASP

```
<html>
  <table border=1 cellpadding=0>
            <tr>
      <td colspan="3" valign=top class="Normal" height="77"
   ><!--#include virtual="/scripts/SCECU/include/Title.inc"--></td>
    </tr>
    <tr>
      <td rowspan="3" valign=top class="Normal" height="231" width=153 align="left"
   ><!--#include virtual="/scripts/SCECU/include/NavBar.inc"-->
<FORM ACTION="/scripts/SCECU/list/list.asp" METHOD=POST>
<b>Chemical Search</b><br>
<INPUT type=text name="keyword" size=15 value="<%=Keyword%>">
<INPUT type=submit value="Search">
</FORM>
</td>
<html>
<%
Keyword = Request.Form("keyword")
Set Conn = Server.CreateObject("ADODB.Connection")
Conn.Open "SCECU"
            sql="SELECT * FROM tbl_list"
            sql=sql&" WHERE (Compound_Name like '%"&Keyword&"%')"
            Set RS = Conn.Execute(sql)
            'response.write sql
%>
<td>
<table border =1>
<%

count = RS.Fields.Count -1
For i = 0 to count %>

            <td>
            <B><% = RS(i).Name %></B></TD></td>
<% Next %>
</TR>
<% Do While Not RS.EOF %>
            <TR>
            <% For i = 0 to RS.Fields.Count - 1 %>
                        <TD VALIGN=TOP><% = RS(i) %></TD>
            <% Next %>
            </TR>
            <%
            RS.MoveNext
```

```
Loop
RS.Close
Conn.Close
%>
</table>
</html>
```

APPENDIX I: CONFERENCE PROCEEDINGS

Exchange Programs for Chemicals and other Hazardous Wastes in North America

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Abstract

Industry in North America has found that *waste exchanges* are useful tools for reducing disposal and purchasing costs for new materials. The industrial waste exchange programs in North America function with small budgets and minimal staffs. The majority of exchanges deal only with information, without ever handling the wastes. A list of materials to be shared is compiled and distributed electronically or in print. The exchange may collect and distribute the information about its chemicals in a passive manner or more actively by seeking buyers and sellers. The program may be funded by grants, advertising fees, listing fees, or transaction fees. Almost all exchanges are subsidized by government funding.

There are some universities in the United States and Canada that run an exchange solely within their campuses. There are still other chemical exchanges called consortiums that are managed by universites but may also encompass from industries in the local area. Efforts are currently being made to implement an exchange for reusable chemicals at Chulalongkon University.

Keyword : Academic and Industrial Waste Exchange

1 Introduction

New technologies are developed, ultimately, to assist the survival of society and improve quality of life. With the current rate at which industry extracts raw materials, the sustainability of our lifestyles is certainly finite. Thailand, for instance, creates a total of 1.6 tons of hazardous waste annually, 73% of which is generated by industry alone. In order to allow society to continue to better itself indefinitely, industry must strive for minimal impact on the natural world. This goal can be promoted by restructuring industrial practices to become cyclic rather than linear. It must become standard practice for wastes to be resurrected and placed back into use. The behavior of business also has to change to give sustainability the highest priority.

Waste exchanges came about because of concerns within the academic and industrial worlds about increasing volume of waste streams. These programs facilitate the reuse of chemicals that might otherwise have been disposed of. One organization's waste product becomes another organization's raw material. This allows the first to avoid a disposal cost, while the second avoids a purchasing cost, a mutually beneficial situation [1]. In addition to the cost savings, exchanges are environmentally friendly and decrease health risks. The following sections will outline the various forms that chemical waste exchanges take, and methods currently used within academia and industry within North America.

2 Industrial Waste Exchanges

A waste exchange may operate in one of two ways: central or bilateral. A centralized program is one in which the exchange personnel collect, store, and distribute the substances involved. The waste materials are brought to an area designated for storage, where they are evaluated as usable or non-usable. A centralized inventory is kept and distributed either electronically or on paper. A person with access to this inventory can "shop" before purchasing a waste material. In many cases, items listed on the exchange are free, provided that the user can arrange for transportation. The substances can be distributed to teaching laboratories, research facilities, or industrial organizations.

Bilateral systems deal only with information about wastes. The name, quantity, purity, type of container, and owner of the material are included in a database. Like the central exchange, the information can be distributed in electronic or paper format. Some industries have concerns about who knows what chemicals they are using and producing, so exchanges sometimes do not include the name of the owner of a waste chemical. If the owner and contact information is included in the exchange's database, the interested party usually contacts the owner directly and the exchange never handles the material.

Among industrial waste exchanges investigated in North America, it was found that although waste exchange is a highly effective and beneficial process, commercial exchanges seldom deal solely with hazardous waste nor any other particular type of waste product. Rather than running a chemical-specific operation, exchanges function by combining byproduct materials as well as surplus stock such as bulk solvents and acids, metal sludges, glass, wood, recyclable plastics and packaging materials.

Materials exchanges have been growing in popularity over the past few years across the globe and are now in nearly every US state, as well as in Canada and Europe[2]. Many exchanges that were contacted used a database system accessible to interested users. Such a database can be made available as a searchable web page or a modem-based bulletin board. Some exchanges simply use a telephone number (sometimes toll-free) that is staffed during business hours. The customer base for the list itself is obtained in several ways, depending mainly on the budget of the exchange.

Some exchanges will allow any chemicals to be placed on their list while others will not accept materials that are classified as hazardous. One reason for this restriction is the requirement created by the United States Resource Conservation and Recovery Act (RCRA) that all hazardous waste generators take Cradle-to-Grave responsibility. This means that any chemical must have complete owner and location documentation from its creation to its destruction. Any organization that accepts chemicals from off-site and stores them before sending them to another user may have to acquire a *Treatment, Storage, and Disposal Facility (TSDF)* permit. These are difficult to acquire, and there are substantial penalties for operating without a permit. In general, handling hazardous wastes imposes large liabilities on an exchange in the United States.

One parameter affecting the success of a materials exchange seems to be the distance between parties involved. In Ontario, 33% of successful matches are within a distance of 80 km. Only 12% of matches are made between companies over 800 km apart. For this reason, it is important that companies list on local exchanges, as success may be limited with a regional exchange[1].

2.1 Promotion of Industrial Waste Exchanges

As with any business, waste exchanges have a direct interest in the promotion of reuse and recycling activities. Depending on the staffing of material exchanges, strong involvement with the business community may or may not be possible. Promotion of an exchange can be either passive or pro-active. Exchanges commonly advertise at state environmental agencies, trade groups, Chambers of Commerce, newspapers, and trade journals, but the smaller the exchange, the less the employee(s) can afford to spend time on marketing[2].

Passive exchanges rely solely on a catalogs, brochures, or word of mouth to make their listings known. Large quantities of surplus material are best shared through a passive exchange. Sometimes though, small amounts of fine lab chemicals can be successfully swapped[3].

Passive waste exchange programs usually match only 20% - 30% of the wastes listed in their databases. In some US states, companies will list unmatchable wastes on local exchanges simply to prove that they are non-recyclable, and eligible for disposal in a landfill. Other materials, however, are not matched because they require more time and effort to place them than the passive exchange can afford to contribute[1].

The *California Waste Exchange (CWE)* has been part of the California Department of Toxic Substances Control since 1976. CWE shares only information and is thus a passive exchange. CWE is unique because it specializes in hazardous chemical waste. It produces a yearly newsletter and directory of industrial recyclers. Twenty new listings are made each year, allowing the exchange to be run by just one full time person. Most of CWE's listings are surplus lab chemicals or unused hazardous materials[2].

At present, the T*ennessee Materials Exchange (TME)* is a passive materials exchange. Even with one employee, results show that for every dollar spent in the operation, two dollars have been saved by industry. If it had a second employee, the TME could become more active in finding potential matches between generators and receivers.

A pro-active exchange may increase public awareness of its function by seeking companies in need of services, matching generators and consumers, and providing workshops, bulletins, and advertising. These exchanges can provide community assistance by promoting and teaching about resource conservation. Some exchanges even go so far as to give on-site plant assessments of reuse and recycling opportunities[2]. Most exchanges cannot give this level of service because of scarce resources and limited staff expertise[1].

The *Industrial Materials Exchange Service (IMES)* is extremely pro-active and has "Waste Exchange Activators"- one in Chicago and one in southern Illinois. They visit companies and offer waste reduction tips and information about the exchange's operation. They consistently find that companies are not aware of the value of their waste nor the potential for reuse. The site visits performed by the Activators give information that cannot be converged by the telephone or Internet. IMES works with small and large organizations, but finds that many large corporations are cautious because of their liability risks. Overall, half of the companies visited by Activators do not wish to trade and give no reason for their unwillingness[2].

2.2 Costs and Funding of Industrial Waste Exchanges

Individual costs associated with running individual industrial exchanges include computers, office space, catalog printing, and salaries, which may range from that for a single full time employee to part time salaries for up to six workers, as well as compensation for interns. The average budgets of exchange agencies range from $10,000 to $200,000 per year. Annually, the combined budgets of all materials exchanges in the U.S. total less than $3.5 million.

Typically, these budgets are funded through two main sources: private and government funding. The majority of industrial exchanges in the U.S. are at least partially state or federally sponsored, and cannot rely on private funding alone. This does not mean that they are all linked with government agencies. Although most states do have their own exchanges, many exchanges are private, non-profit groups.

Tipping and waste fees for disposal are one method through which state governments try to fund exchanges in an efficient and fair manner. The *Iowa Waste Reduction Center (IWRC)*, for instance, receives $0.10 per ton of waste as a tipping fee by legislative mandate. The *California Materials Exchange (CALMAX)* receives $0.75 per ton. The *Industrial Materials Exchange (IMEX)* in Seattle, relies on of an annual fund which is a small portion of the $9.6 million gathered annually from surcharges on waste disposal in the area[2]. Exchanges also depend on one or more private funding methods which may include a variety of member fees consisting of annual subscription charges, advertisement expenses, listing fees, or purchasing fees.

Material catalogs can cost $5 per copy to produce. Some exchanges try to lower the cost of publication by charging subscription fees. The *Southeast Waste Exchange (SEWE)* charges $25 per year, while the *Pacific Materials Exchange (PME)* charges $48 per year to their subscribers. However, these charges often encourage customers to switch to free exchanges. It was discovered that although subscription fees can balance basic costs, they can never be enough to make an exchange profitable[2].

An additional funding device can be a listing fee. Some exchanges charge listing fees of around $50 for up to 10 materials. With this charge, 400 listers can only generate $20,000 per year, which is not sufficient to cover operating costs. Many exchanges have lost customers due to these fees. The *Northeast Industrial Waste Exchange (NIWE)* had its revenue fall by half after beginning to charge listing fees[2].

Due to problems such as this, exchanges tend to rely on transfer fees alone. This is a fee charged to the lister when a transfer is made successfully. This supplements funding, and also begins to shift the cost from the taxpayer to the companies that actually benefit from the exchange. The Arizona Exchange for example, follows this method.

Advertising revenue is another possible source for meeting budget requirements. However, it rarely yeilds surplus revenue. For example, in addition to their $25 per year subscription fee, the *Southeastern Waste Exchange (SEWE)* also has a $300 charge for a full-page advertisement in its bimonthly catalog. SEWE gained less than $5000 per year from ads in its bimonthly catalog[2].

The *Ontario Waste Exchange (OWE)* is run by ORTECH International of Canada and has sought markets for waste since 1987. It is run by a staff of four people who concentrated on wastes that they deem harder to place. OWE gets a budget of CAN $250,000 yearly. Most of this is provided by the Ontario government. Between 1991 and 1992, exchanges of household and industrial wastes were done through OWE at a cost of CAN $3.50 per ton as compared to curbside pickups of $100-$200 Canadian per ton. Hazardous household waste programs can cost $2000-$10,000 per ton for disposal. This is dramatically higher than the cost of using OWE.

2.3 Brokerages

Brokerages are for-profit private companies that act as the middleman in an exchange. They actively seek out markets for wastes, using waste exchanges as cheap sources of material. Brokers, like exchanges, usually operate bilaterally. To ensure them selves of a profit, brokers often a written contract from both parties for a fixed percentage or price per unit of the materials being sold. Thus both buyer and seller of hazardous waste know who the other party is and can be sure that the transaction doesn't pose some kind of liability risk. For the broker, however, the only way to ensure that future transactions include his payment is to make a long term, exclusive contract during the first transaction.

2.4 Consortiums

Waste exchanges within academic settings generally deal with strictly reusable chemical waste. In fact, with university waste streams averaging 16 metric tons annually, and the possibility of reclaiming half of these wastes, chemical re-use can be a very profitable business. Portland State University Chemical Consortium, for example, has been successful for nearly 10 years. Its membership encompasses 72 parties within a 800 km radius, ranging from primary and secondary education facilities to local industry and small businesses. The exchange is run through a centralized system utilizing its own Health and Safety Administrator as manager, as well as six employees. They are housed by a facility on the outskirts of the university's campus whose rent constitutes for a large portion of their operating costs. An annual budget of $6,000 is funded by membership fees, with industry paying much more than smaller waste producers. Compensation for this fee, is offered through two distinct programs, the Chemical Waste Management Program and the Chemical Exchange Program. Each of these can be a tool in greatly subsidizing handling and disposal costs for any waste generator.

At Chulalongkorn University efforts are now being made to implement a chemical waste exchange program of this nature. It is anticipated that the operation will be bilateral, and passive. Ideally, the amount of usable waste disposed of will decrease sharply which in turn will decrease the need for acquisition of new chemicals, cut human health risks associated with poor waste management, and slow environmental degradation.

3 Conclusion

A prominent problem with the current pricing of raw materials is that businesses are not charged the true cost of raw material extraction, energy production, and waste management. This allows companies to under utilize the resources they obtain. Presently, we have an inefficient economy that squanders raw materials, energy, and environmental health because the market doesn't recognize them as scarce commodities and charge accordingly[1].

Paul Hawken, environmentalist and board member of The Natural Step, writes, "We are far better at making waste than at making products. For every 100 pounds of product we manufacture in the United States, we create at least 3,200 pounds of waste. In a decade, we transform 500 trillion pounds of molecules into nonproductive solids, liquids and gases." If conducted correctly, waste exchanges can provide lower disposal costs, reduced refuse quantities, less strain on natural resources, and in increase in the value of waste. The EPA approximates that industry generates 7.6 billion tons of solid waste alone each year. With such a massive amount of waste going to landfills and incineration, the expansion potential for waste exchanges is tremendous[4].

References

[1] "RCBC Reiterate," October 1996; available from http://www.rcbc.bc.ca/publications/reiterate/1096; accessed November 1996.

[2] "A Review of Industrial Waste Exchanges," United States Environmental Protection Agency, September 1994; available from http://es.epa.gov/program/regional/trade/review.html; accessed November 1999.

[3] "Less is Better: Laboratory Chemical Management Waste Reduction," American Chemical Society, 30 November 1999; available from http://www.acs.org/government/publications/tech_lessisbetter.html; accessed November 1999.

[4] "Industrial Waste Exchange," Environmental Health Perspectives, August 1993; available from http://ehpnet1.niehs.nih.gov/docs/1993/101-3/forum.html#industry; accessed November 1999.

APPENDIX J: CHEMICAL WASTE GENERATION STATS, THAILAND

APPENDIX J.1: UNIVERSITY GENERATED WASTE

APPENDIX J.2: WASTE MANAGED

APPENDIX J.3: WASTE REUSED

Appendix J.1

TABLE E12 - AVERAGE WASTE GENERATION RATE FROM SURVEY AND ADJUSTED VALUES
UNIVERSITY AND COLLEGE LABORATORY

SURVEY DATA - KG/YEAR/EMPLOYEE

# OF SURVEYED GENERATORS		76	10	15	14	9	20		
	WASTE	BANGKOK	VICINITY	CENTRAL	NORTHEAST	NORTH	SOUTH	NATIONAL WEIGHTED (POOLED) AVERAGE	PUBLISHED VALUES
I1	Ignitable, Organic Wastes	13.44	2.96	0.72	0.07	0.16	0.08	1.43749292	
C2	Liquid, Acids/Alkalies	4.52	0.65	1.18	0.09	0.51	0.01	0.52364907	
R1	Reactive Chemicals	16.67	54.26	8.17	1.23	135.96	4.40	9.98287366	
T2	Liquid, Heavy Metals	0.007	0.00	0.40	0.0015	11.52	0.0026	0.41425982	
T3	PCBs	1.08	1.07	0.74	0.02	0.09	0.0044	0.14062099	
T5	Misc Toxic Chemicals	8.70	15.52	4.24	4.76	7.78	0.16	2.29102804	
T10	Dry Cell Batteries	0.00	0.00	0.00	0.02	0.00	0.00	0.0244606	
T11	Fluorescent Light Bulbs	1.56	2.30	1.54	0.02	0.06	0.04	0.23618797	
IN1	Medical Wastes	13.54	1.10	169.61	5.05	12.07	2.96	8.8598157	
O2	Partially Unreacted Chemicals	9.99	18.00	0.33	1.30	46.00	0.05	2.9648493	
	Total CGHW	69.51	95.86	186.93	12.55	214.15	7.72	26.87523867	
W103	Cleaning chemicals (detergents, bleach) (T5)	8.70	15.52	4.24	4.76	7.78	0.16	6.86	
W304	Unused Organic Reagents (I1)	12.81	0.76	0.72	0.03	0.08	0.08	2.41	

SURVEY DATA - KG/YEAR/ESTABLISHMENT

	WASTE	BANGKOK	VICINITY	CENTRAL	NORTHEAST	NORTH	SOUTH	NATIONAL WEIGHTED (POOLED) AVERAGE	PUBLISHED VALUES
I1	Ignitable, Organic Wastes	143.06	13.63	9.73	6.95	4.98	21.72	33.35	
C2	Liquid, Acids/Alkalies	48.09	3.00	16.00	8.99	16.13	3.87	16.01	
R1	Reactive Chemicals	177.45	249.60	111.08	129.77	4275.33	1176.34	1019.93	
T2	Liquid, Heavy Metals	0.07	0.00	5.40	0.16	362.10	0.70	61.41	
T3	PCBs	11.52	4.90	10.06	1.70	2.76	1.17	5.35	
T5	Misc Toxic Chemicals	92.56	71.40	57.60	500.81	244.60	43.60	168.43	
T10	Dry Cell Batteries	0.00	0.00	0.00	2.57	0.00	0.00	0.43	
T11	Fluorescent Light Bulbs	16.57	10.59	20.93	1.95	1.96	10.16	10.36	
IN1	Medical Wastes	144.17	5.04	2306.70	531.17	379.55	792.22	693.14	1120 [1]
O2	Partially Unreacted Chemicals	106.38	82.80	4.46	136.29	1446.40	14.52	298.48	
	Total CGHW	739.87	440.96	2541.96	1320.36	6733.81	2064.30	2306.88	
W103	Cleaning chemicals (detergents, bleach) (T5)	92.56	71.40	57.60	500.81	244.60	42.25	168.20	
W304	Unused organic reagents (I1)	136.39	3.50	9.73	3.43	2.51	20.49	29.34	

NOTES:

(1) Engineering Science, Thai: DCI Co., LTD., 1989.

Adjusted rate

TOTAL	304,131,221	83,680,273.87	216,966,743.35	219,401,291.89	32,408,682.95	5,103,696.13	6,018,917.58	153,818,590.63	57,708,582.64	7,133,601.77	25,962,775.45	31,045,435.57	28,462,234.9[illegible]

[illegible]

Report Id: [illegible]

NATIONAL SUMMATION DATA ESTIMATES FOR ALL OF NATION'S REGIONS

Estimated Breakdown Of Management Practice By Generator Type (Kg/year)

Major Generator Category	Total Waste Generated (Kg/Year)	Waste Management Practice											
		Commingle	Separate	Container Storage	Non-Container Storage	Other	Treatment	Re-Use	Co-disposal w/MSW	Burning / Medical Incinerator	To Environment	To Sewer	Other
Automotive	149,476,532	28,400,857.69	121,075,652.96	113,446,291.14	28,9?1,661.39	713,791.07	897,850.22	120,412,639.13	11,648,041.83	1,128.62	2,775,140.26	3,015,760.35	11,623,821.78
Photographic processing	4,992,864	842,662.02	4,149,972.04	4,249,974.30	58,232.07	84,889.07	70,019.90	2,580,123.44	468,105.49		333,336.02	1,224,014.84	387,284.17
Dry cleaning and laundry	212,342	132,299.24	73,429.39	144,302.31	988.60	1,868.97	421.33	8,141.92	102,481.88		5,786.30	58,138.66	37,793.22
Commercial printing	3,895,874	1,448,193.37	2,424,931.26	3,471,511.55	29,299.99	877.63	34,717.84	1,198,410.51	1,736,893.75		133,105.24	723,278.33	104,186.15
Gas Station	28,555,259	7,174,088.14	21,250,689.12	26,727,274.97	667,931.01	97,323.03	207,564.37	19,470,220.39	2,229,232.40	20,942.70	978,785.61	1,138,021.72	4,718,056.14
Hotels	902,075	503,395.43	385,990.02	432,749.39	1,185.24	12,284.69	182,788.98	1,348.43	365,135.27	990.92	102,576.61	392,159.12	39,864.63
Airports	40,231	6,817.42	26,125.98	30,655.18	430.73		4,297.75	23,931.39	6,118.13		1,730.92	514.60	7,935.94
Seaports	567,819	44,038.51	511,082.24	423,677.26	84,711.65	25,946.30	40,033.17	233,208.32	105,753.71	247.25	64,323.47	13,086.13	151,200.09
Railroad maintenanace	1,212,229	712,463.42	494,989.49	967,986.95	184,185.44		30,420.17	816,858.76	185,745.67	1,042.08	39,443.48	382.53	168,756.45
Military installations													
Hospitals	14,849,578	2,458,412.05	12,376,623.83	11,318,347.25	194,327.01	333,061.38	4,069,338.66	418,766.99	4,014,511.36	5,370,064.07	443,690.25	3,592,230.81	1,010,314.5[illegible]
Laboratories	2,341,912	604,496.33	1,734,490.84	1,577,498.20	26,673.33	53,254.43	446,017.40	24,771.16	824,739.47	153,753.81	112,507.95	1,120,539.93	105,599.6[illegible]
Agriculture - Farms	30,466,488	5,002,088.49	24,695,212.85	19,842,004.46	1,932,501.28	3,246,232.69	1,681.08	7,294,219.78	4,165,128.98	1,585,432.27	14,261,145.96		3,160,560.9[illegible]
Electrical transmission	82,486	447.00	40,797.42	36,135.75	5,100.00		7,500.00	22,426.84	435.75		11.25	8.67	59,603.4[illegible]
Residental	66,535,532	36,350,014.69	27,726,755.85	36,732,883.11	231,455.15	534,166.81	26,266.63	1,313,523.52	31,856,258.90		6,711,192.08	19,767,299.82	6,887,257.6[illegible]
TOTAL	304,131,221	83,680,273.87	216,966,743.35	219,401,291.89	32,408,682.95	5,103,696.13	6,018,917.58	153,818,590.63	57,708,582.64	7,133,601.77	25,962,775.45	31,045,435.57	28,462,234.9[illegible]

Returnable Anesthetic Gases (O3)	355 48

NATIONAL SUMMATION DATA ESTIMATES FOR ALL OF NATION'S REGIONS

Estimated Breakdown Of Re-Use Method By Generator Type (Kg/year)

Major Generator Category	*Total Waste Re-Used (Kg/Year)*	*Re-Use Method*									
		Solvent recovery	*Metals recovery*	*Acid or base regeneration*	*Oil/water separation*	*Lead/acid battery recycling*	*Use as fuel for energy generation*	*Recycle/reuse for agricultural purposes*	*Separation and removal by scavengers*	*Sale*	*Other*
Automotive	120,412,639 13	644 97			1,297 67	743,185.98	83,579.88	20 70	353,936 22	118,104,341 81	1,125,631 87
Photographic processing	2,580,123 44		6,935 17							2,532,197 37	40,990 89
Dry cleaning and laundry	8,141 92								129 49	7,721 69	290 73
Commercial printing	1,198,410 51		4,107 74		302 65				2,417 62	1,169,563 45	22,019 03
Gas Station	19,470,220 39	661 32			670 47				49,081 60	19,319,882.53	99,924 45
Hotels	1,348 43							137 12		1,211.31	
Airports	23,931 39									19,102 74	4,828 64
Seaports	233,208 32				14,589 67	19,133 56	72 17			172,491 74	26,921 16
Railroad maintenanace	816,858 76						473,217 78			254,959 64	88,681 32
Military installations											
Hospitals	418,766 99	90,187 74	0 91			0 81		21,960 70	2,742 67	285,819 63	18,054 50
Laboratories	24,771 16	7,327 30			7,739 90			3,455 51		15 25	6,233 17
Agriculture - Farms	7,294,219 78						174,009 44	702,756 36		2,543,389 40	3,874,064 56
Electrical transmission	22,426 84									7,500 00	14,926 84
Residental	1,313,523 52									108,875 82	1,204,647 69
Total	***153,818,590.63***	***98,821 35***	***11,043.83***		***24,600.38***	***762,320.36***	***730,879.29***	***728,330.42***	***408,307.63***	***144,527,072.44***	***6,527,214 91***

APPENDIX K: THE FACTORY ACT OF 1992

(GARUDA EMBLEM)

THE NOTIFICATION OF THE MINISTRY OF INDUSTRY NO. 6. [B.E. 2540(1997)] ISSUED PURSUANT TO THE FACTORY ACT B.E. 2535(1992) SUBJECT : DISPOSAL OF WASTES OR UNUSABLE MATERIALS

(Unofficial Translation)

By virtue of Article 13(3), Article 13(3)(a) and Article 13(3)(b) of the Ministerial Regulations No. 2 [B.E. 2535 (1992)] issued pursuant to the Factory Act B.E. 2535(1992), the Minister of Industry issues a notification as follows :-

Article 1. Factory operators having wastes or unusable materials which have such characteristics and properties as defined in Annex 1 hereto must carry out the disposal of the wastes or unusable materials as defined in Article 2 and Article 3.

Article 2. The wastes or unusable materials under Article 1 shall not be taken out of the factory except with prior approval from the Director-General of Industrial Works Department or the person assigned by Director-General of Industrial Works Department to take them out to detoxify, dispose, discard or landfill by method and at the place according to the criterion and the method defined in Annex 2 hereto.

Article 3. Details on type, quantity, characteristics, properties and storing place of the wastes or unusable materials concerned as well as method of storage, detoxification, disposal, discarding, landfilling and transport according to "Form Ror. Ngor. 6", attached hereto must be notified to the Department of Industrial Works within the limit of 90 days from the effective date hereof, except that factory operators who operate a factory after the effective date hereof shall notify within the limit of 90 days from the commencing date of factory operation.

The details under paragraph one must be further notified every year by 30th day of December and this notice may be done by receipt-returned registered mail, which shall be deemed to be received on the date delivered by the postman.

This shall, thus, come into force after the date of the publication hereof in the Royal Government Gazette.

Announced on the 29th October 1997.

(Signed): Korn Thappharangsi
(Mr. Korn Thappharangsi)
Minister of Industry.

Published in the Royal Government Gazette, Volume 114, Special Section 106 Ngor. dated 13th November 1997. (B.E.2540)

ANNEX 1

LIST OF CHARACTERISTICS AND PROPERTIES OF WASTES OR UNUSABLE MATERIALS ATTACHED TO THE NOTIFICATION OF THE MINITSTRY OF INDUSTRY NO. 6 [B.E. 2540(1997)]

Section 1

Wastes or Unusable Materials of the Categories of Ignitable Substances, Corrosive Substances, Reactive Substances, Toxic Substances and Leachable Substances

Article 1. Ignitable substances with characteristics and properties as follows :-

1.1 Being a liquid with flash point less than 60 degrees Celsius (140 degrees Fahrenheit) but not including an aqueous solution with alcohol content less than 24 percent by volume, the test method or the analysis method measured by Pensky Martens Closed Cup Tester according to the test method of ASTM Standard D-93-79 or D-93-80 or by the Setaflash Closed Cup Tester according to the test method of ASTM Standard D-3278-78.

1.2 Being a substance other than liquid but capable of causing fire through fiction, absorption of moisture or spontaneous chemical reaction when ignited will burn vigorously and continuously, causing a severe hazard under the standard temperature and pressure (Pressure of 1 atmosphere and temperature of 0 degree Celsius).

1.3 Being an ignitable compressed gas, which shall mean any material or mixture contained in a container with absolute pressure more than 2.81 kilograms per square centimeter (40 pounds per square inch) at 21 degrees Celsius (70 degree Fahrenheit) or with absolute pressure more than 7.31 Kilogram per square) at 55 degrees Celsius (130 degree Fahrenheit), the test method or the analysis method done by measurement according to the test method of ASTM Standard
D-323.

1.4 Being an oxidizer which gives oxygen quickly and is capable of exciting the combustion of organic substances, e.g. chlorate, permanganate, inorganic peroxide and nitrate.

Article 2. Corrosive substances with characteristics and properties as follows :-

2.1 Being an aqueous substance with pH equal to or less than 2 and pH equal to or more than 12.5, the test method of the analysis method measured by the pH-meter according to the test method of US.EPA. Method 9040.

2.2 Being a liquid capable of corroding steel of the class of SAE 1020 at a rate higher than 6.35 millimeters (0.250 inch) per year at temperature of 55 degrees Celsius (130 degrees Fahrenheit), the test method or the analysis method measured by the method of NACE (National Association of Corrosion Engineers) Standard TM-01-69.

Article 3. Reactive substances with characteristics and properties as follows :-

3.1 Being a substance with unstable condition and capable of reacting quickly and violently without detonating.

3.2 Being a substance which reacts violently with water.

3.3 Being a substance which, when combined with water, will yield an explosive mixture.

3.4 Being a substance which, when combined with water, will generate toxic gases, toxic vapor, or toxic fumes in a quantity potential to cause a hazard to human health and the environment.

3.5 Being a substance consisting of cyanide or sulfide which, when having pH between 2 to 11.5, will generate a toxic gas, toxic vapor or toxic fume in a quantity potential to cause a hazard to human health and the environment.

3.6 Being a substance which, when heated in a confined space, will have a reaction of exploding viorently or when being in a place where there is the standard temperature and pressure (pressure of 1 atmosphere and temperature of 0 degree Celsius) will have a viorently reaction and may explode.

Article 4. Toxic substances with characteristics and properties as follows :-

4.1 Being a substance hazardous to human health by causing death in only a small quantity, the test method or the analysis method measured by the US EPA Method of toxicity test.

4.2 Being a substance with characteristics and properties as follows :-

When rats are used as experimental animals, LD_{50}(Oral LD_{50}) is less than 50 milligrams per kilogram of the body weight or LC_{50} (inhalation LC_{50}) less than 100 parts per million (vapor or gas) or when rabbits are used as experimental animals, LD_{50}(dermal rabbit LD_{50}) is less than 32 milligrams per kilogram of the body weight, in which case LD_{50} means the medium lethal dosage causing the death of one half of the animals used in the experiment (50%), LD_{50} having its unit in milligrams of substance per kilogram of the animal body weight, and LC_{50} means the medium lethal concentration in the medium causing the death of one half of the animals used in the experiment (50%), LC_{50} having its unit in parts (by volume or weight) of substance per million of the medium.

4.3 Being a substance generated from a production process containing or contaminated with carcinogen under the list in Group 1, Group 2A and Group 2B of the International Agency for Research on Cancer (IARC).

4.4 Being a substance toxic to experimental aquatic life with LC_{50} less than 5 milligram per liter within 96 hours.

4.5 Being a substance which, when diluted for concentration less than 20 percent, still causes LC_{50} to the experimental animals within 96 hours.

Article 5. Leachable substances are substances which, when extracted by the leachate extraction procedure and the extract analysis method under the criterion specified in Article 3 of Annex 2 hereto, has heavy metals or toxic materials content in the extract equal to or more than any of the following values :-

Arsenic (total)	5.0	mg/l
Barium	100.0	mg/l
Benzene	0.5	mg/l
Cadmium (total)	1.0	mg/l
Carbon tetrachloride	0.5	mg/l
Chlordance	0.03	mg/l
Chlorobenzene	100.0	mg/l
Chloroform	6.0	mg/l
Chromium (total0	5.0	mg/l
Ortho-Cresol	200.0	mg/l
Meta-Cresol	200.0	mg/l
Para-Cresol	200.0	mg/l
Cresol (total)	200.0	mg/l
2-4 D	10.0	mg/l
1,4-Dichlorobenzene	7.5	mg/l
1,2-Dichloroethane	0.5	mg/l
1,1-Dichloroethylene	0.7	mg/l
Endrin	0.02	mg/l
Heptachlor and its epoxide	0.008	mg/l
Hezachlorobenzene	0.13	mg/l
Hezachlorobutadiene	0.5	mg/l
Hezachloroethane	3.0	mg/l
Leand (total)	5.0	mg/l
Lindane	0.4	mg/l
Mercury (total)	0.2	mg/l
Methozychlor	10.0	mg/l
Methyl ethyl ketone	200.0	mg/l
Nitrobenzene	2.0	mg/l
2,4-Nitrotoluene	0.13	mg/l
Pentachlorophenol	100.0	mg/l
Pyridine	5.0	mg/l
Selenium	1.0	mg/l
Silver	5.0	mg/l
Tetrachloroethylene	0.7	mg/l
Tozaphene	0.5	mg/l
Trichloroethylene	0.5	mg/l
2,4,5-Trichlorophenol	400.0	mg/l
2,4,6-Trichlorophenol	2.0	mg/l
2,4,5-TP (Silvex)	1.0	mg/l
Vinyl Chloride	0.2	mg/l

Section 2

Wastes or Unusable Materials From Non-specific Sources and Specific Sources

Article 6. Hazardous wastes from non-specific sources with characteristics and properties as follows :-

6.1 Spent halogenated solvents which are used in degreasing process, i.e. tetrachloroethylene, trichloroethylene, methylene chloride, 1,1,1 - trichloroethane, carbon tetrachloride, chlorinated fluorocarbon, including the case of being a mixture with other solvent used in the degreasing process, in which before being used there is one or more kinds of such solvent in a quantity of 10 per cent or more (by volume) and still bottoms generated from the recovery process from the mixture of such solvents.

6.2 Spent halogenated solvents, i.e. Tetrachloroethylene, Methylene chloride, Trichloroethylene, 1,1,1 - trichloroethane, Chlorobenzene, 1,1,2 - trichloro - 1,2,2 - trifluroethane, ortho-dichlorobenzene, trichlofluoro methane, 1,1,2 - trichloroethane, including the case of being a mixture with other solvents, in which before being used there is one or more kinds of such solvent mixed in a quantity of 10 per cent or more (by volume) and still bottoms generated from the recovery process from the mixture of such solvents.

6.3 Spent non-halogenated solvents of Group 1, i.e. Xylene, Acetone, Ethyl acetate, Ethyl benzene, Ethyl ether, Methyl isobutylketone, N-butyl alcohol, Cyclo hexanone and Methanol, including the case of being a mixture with other kinds of solvent, in which before being used there is one or more kinds of such solvent mixed in a quantity of 10 percent or more (by volume) and still bottoms generated from the recovery process from the mixture of such solvents.

6.4 Spent non-halogenated solvents of Group 2, i.e. Cresols, Cresylic acid and Nitrobenzene, including a mixture of other solvents, in which case before being used there is one or more kinds of such solvent mixed in a quantity of 10 percent or more (by volume) and still bottoms generated from the recovery process from the mixture of such solvents.

6.5 Spent non-halogenated solvents of Group 3, i.e. Toluene, Methyl ethyl ketone, Carbon disulfide, Isobutanol, Pyidine, Benzene, 2-ethoxyethanol and 2-nitropropane, including a mixture of other solvents, in which case before being used there is one or more kinds of such solvent mixed in a quantity of 10 percent or more (by volume) and still bottoms generated from the recovery process from the mixture of such solvents.

6.6 Wastewater treatment sludges from electroplating operations, except from the process of sulfuric acid anodizing of aluminium, the process of tin plating on carbon steel, the process of zinc plating on carbon steel, the process of aluminium or zinc plating on carbon steel, including cleaning/stripping water from the processes of plating carbon steel with tin, zinc and aluminium and chemical agents used in the etching and milling of aluminium.

6.7 Spent cyanide plating bath solutions from electroplating.

6.8 Plating bath residues from bottom of plating bath using cyanide in the plating process.

6.9 Spent solution from cleaning stripping using cyanide in the electroplating processes.

6.10 Quenching bath residues from oil baths in the metal heat treating operations using cyanide in the process.

6.11 Spent cyanide solution from cleaning workpieces by the salt bath pot cleaning method from metal heat treating operations.

6.12 Sludges of the wastewater treatment system from quenching in metal heat treating operation using cyanide in the process.

6.13 Wastewater treatment sludge from chemical conversion coating, of aluminium except from zirconium phosphating in aluminium can washing operations.

6.14 Wastes from the production or industrial use of tri- or tetrachlorophenol or of an intermediate in the production of chlorophenol derivatives, which is used to serve as reactant or chemical intermediate or component in the formulating process. This does not include wastes from the production of hexachlorophene from purified 2, 4, 5 - trichlorophenol and except wastewater and spent carbons from the process of hydrogen chloride purification.

6.15 Wastes from the production or industrial use of pentachloro phenol or of an intermediate used in the production of pentachloro phenol derivatives, which is used to serve as reactant or chemical intermediate or component in the formulating process, except wastewater and spend carbons from the process of hydrogen chloride purification.

6.16 Wastes from the production or industrial use of tetra-, penta- or hexachlorobenzenes in the alkaline condition, which is used to serve as reactant or chemical intermediate or component in the formulating process, except wastewater and spent carbons from the process of hydrogen chloride purification.

6.17 Wastes from the production of any material or substance using tools or devices used in the production process of tri- and tetrachlorophenols, which does not include wastes from the tools or devices used only in the production (or use) of hexachlorophene from purified 2, 4, 5 - trichlorophenol and except wastewater and spent carbons from the process of hydrogen chloride purification.

6.18 Wastes from the production process of chlorinated aliphatic hydrocarbons using free radical catalyzed process, including distillation residues, heavy ends, tars and wastes from reaction tank cleaning from the production process of chlorinated aliphatic hydrocarbons by using free radical catalyzed process, these chlorinated aliphatic hydrocarbons may have a carbon chain length from 1 to 5 and regardless of what quantity and position of a chlorine substitute or at any position. This does not include wastewater sludges from the wastewater treatment and spent catalysts.

6.19 Condensed light ends, filter aids and spent desiccants from the production of chlorinated aliphatic hydrocarbons using free radical catalyzed process. These chlorinated aliphatic hydrocarbons may have carbon chain length from 1 to 5 and regardless of any quantity and position of a chlorine substitution or at any position.

6.20 Wastes from the production of any material or substance using tools or devices in the production or industrial use process of tetra-, penta-, hexa-chlorobenzene in the acid condition, which is used to serve as reactant or chemical intermediate or component in the formulating process, except wastewater and spent carbons from the process of hydrogen chloride purification.

6.21 Discarded unused formulations containing tre, -tetra or penta chlorophenol compound derived from tri-, tetra- or penta chlorophenol: this does not include discarded unused formulations containing hexachlorophenol synthesized from purified 2, 4, 5 - trichlorophenol.

6.22 Residues from incineration or thermal treatment of soil contaminated soil with wastes or unusable materials under Article 6.14, Article 6.15, Article 6.16, Article 6.17, Article 6.20 and Article 6.21.

6.23 Wastewater and residues form wood preserving process including preservative drippage and spent formulation in factory using chlorophenolic except wastewater not contaminated from the process.

6.24 Wastewater and residues from wood preserving process using creosote formulation including preservative drippage and spent formulation, not including wastewater treatment sludge from wood preserving process using creosote or pentachlorophenol and except wastewater not contaminated from the process.

6.25 Wastewater or residues from the wood preserving process in factories using inorganic preservatives containing arsenic and chromium, including preservative drippage and spent formulations, not including wastewater treatment sludges arising from the wood preserving process using creosote or pentachlorophenol and except wastewater not contaminated from the producing process.

6.26 Primary sludges of petroleum refinery derived from oil/water/solids separation, including any oil sludge, water or solid derived from sludge gravitational separation in wastewater storage or treatment or from oily cooling wastewater sludge, sludges arising in oil / water / solid separators in tanks and impoundments, in ditches, in conveyances, in sumps and in stormwater units whether receiving or not receiving dry weather flows, sludges arising from the separation of cooling water or cooling water mixed with oil, biological treatment system sludges, including sludges arising from other treatment units after biological treatment.

6.27 Emulsified secondary sludges of petroleum refinery derived from oil/water/solids separation, including any sludges or floats arising from physical or chemical separation of oil, water, solids in the wastewater treatment process (including wastewater from cooling), which sludges include sludges and floats arising in the process of separating sludges with air foams or induced air flotation (IAF), sludges in tanks and impoundments and all sludges arising in DAF (dissolved air flotation) system, sludges arising in stormwater units not receiving dry weather flows, sludges arising from the separation of cooling water and cooling water mixed with oil, biological treatment system sludges, including sludges arising from other treatment units after biological treatment.

Article 7. Hazardous wastes from specific sources with characteristics and properties as follows :-

7.1 Wood preservation industry, i.e. wastewater treatment sludges from the process of wood preservation with creosote or pentachloro phenol.

7.2 Inorganic pigments production industry, i.e. wastewater treatment sludges from the production process of chrome yellow and orange pigments, molybdate orange pigments, zinc yellow pigments, chrome green pigments, chrome oxide green pigments, both anhydrous and hydrated forms, iron blue pigments, including oven residues from the chrome oxide green pigment.

7.3 Organic chemicals production industry, i.e.

7.3.1 Distillation bottoms in the production of acetaldehyde from ethylene.

7.3.2 Distillation side cuts in the production of acetaldehyde from ethylene.

7.3.3 Bottom stream from wastewater strippers in the production of acrylonitrile.

7.3.4 Bottom stream from acrylonitrile column in the production of acrylonitrile.

7.3.5 Bottoms from acrylonitrile purification column in the production of acrylonitrile.

7.3.6 Still bottoms in the distillation of benzyl chloride.

7.3.7 Distillation residues or heavy ends in the production of carbon tetrachloride.

7.3.8 Heavy ends or still bottoms from purification column in production of epichlorhydrin.

7.3.9 Heavy ends from fractionation column in the production of ethyl chloride.

7.3.10 Heavy ends from the distillation of ethylene dichloride in the production of ethylene dichloride.

7.3.11 Heavy ends from the distillation of vinyl chloride in the production of vinyl chloride monomers.

7.3.12 Wastewater from use of the antimony catalyst in the production of fluoromethane.

7.3.13 Distillation bottom tars in the production of phenol/acetone from cumen

7.3.14 Distillation light ends in the production of phthalic anhydride from naphthalene.

7.3.15 Distillation bottoms in the production of phthalic anhydride from naphthalene.

7.3.16 Distillation bottoms in the production of nitrobenzene by the nitration of benzene.

7.3.17 Stripping still tails from the production of methyl ethyl pyridine.

7.3.18 Residues from centrifugation and distillation in the production of toluene diisocyanate.

7.3.19 Spent catalysts from the hydrochlorinator in the production of 1,1,1 - trichloroethane.

7.3.20 Wastes from the product stream stripper in the production of 1,1,1 - trichloroethane.

7.3.21 Column bottoms or heavy ends in the joint production of trichloroethylene and perchloroethylene.

7.3.22 Distillation bottoms in the production of aniline.

7.3.23 Distillation bottoms or fractionation column bottoms in the production of chlorobenzene.

7.3.24 Distillation light ends in the production of phthalic anhydride from ortho-xylene.

7.3.25 Distillation bottoms in the production of phthalic anhydride from ortho-xylene.

7.3.26 Distillation bottoms in the production of 1,1,1 - trichloroethane.

7.3.27 Heavy ends from heavy ends column in the production of 1,1,1 - trichloroethane.

7.3.28 Residues from the distillation of aniline in the production of aniline.

7.3.29 Combined wastewater in the production of nitrobenzene and aniline.

7.3.30 Wastewater separated from the reactor product washing procedure in the production of chlorobenzene.

7.3.31 Column bottoms from product separation in the production of 1,1 - dimethyl hydrazine or UDMH from carboxylic acid hydrazine.

7.3.32 Condensed column overheads from product separation procedure and condense reaction vent gases from the production of 1, 1 dimethyl hydrazine or UDMH from carboxylic acid hydrazine.

7.3.33 Filter cartridges from product purification procedure in the production of 1,1 - dimethyl hydrazine or UDMH from carboxylic acid hydrazine.

7.3.34 Condensed column overheads from intermediates separation procedure in the production of 1,1 - dimethyl hydrazine or UDMH from carboxylic acid hydrazine.

7.3.35 Wastewater in dinitrotoluene production by nitration of toluene.

7.3.36 Reaction by-products from drying column in toluenediamine production by hydrogenation of dinitrotoluene.

7.3.37 Condensed liquid light ends from toluene diamine purificaiton procedure in the Toluene diamine production by hydrogenation of dinitrotoluene.

7.3.38 Vicinals from toluenediamine purification in toluened amine production by hydrogenation of dinitrotoluene.

7.3.39 Heavy ends from toluenediamine purification procedure in toluenediamine production by hydrogenation of dinitrotoluene.

7.3.40 Organic condensate from solvent recovery column in toluene diisocyanate production by phosphogenation of toluenediamine.

7.3.41 Wastewater from reactor vent gas scrubber in ethylene dibromide production by bromination of ethene.

7.3.42 Spent absorbent solids from purification of ethylene dibromide in ethylene dibromide production by bromination of ethene.

7.3.43 Still bottoms from purification of ethylene dibromide in ethylene dibromide production by bromination of ethene.

7.3.44 Distillation bottoms in production of alpha-/methyl-/ring-chlorinated toluene, benzoyl chlorides and compounds with a mixture of such functional groups, except still bottoms from benzyl chloride distillation.

7.3.45 Organic residuals from spent chlorine gas and hydrochloric acid recovery in production of alpha-/methyl-/ring-chlorinated toluene, benzoyl chlorides and compounds with a mixture of such functional groups, except spent carbon absorbents.

7.3.46 Wastewater Treatment sludges from production of alpha-/methyl-/ring-chlorinated toluene, benzoyl chlorides and compounds with a mixture of such functional groups, except sludges from neutralization and biological sludges.

7.4 Inorganic chemicals production industry, i.e.

7.4.1 Brine purification muds from chlorine production by mercury cell in which separately per purified brine is not used.

7.4.2 Chlorinated hydrocarbon wastes from purification procedure in chlorine production by diaphragm cell.

7.4.3 Wastewater treatment sludges from chlorine production by mercury cell.

7.5 Pesticide production industry, i.e.

7.5.1 By-products salts generated in MSMA and cacodylic acid production .

7.5.2 Wastewater treatment sludges in chlordane production .

7.5.3 Wastewater and water from scrubbing from chlorination of cyclopentadiene in chlordane production .

7.5.4 Filter solids from hexachloro cyclopentadiene filtration in chlordane production .

7.5.5 Wastewater treatment sludges in creosote production .

7.5.6 Still bottoms from toluene recovery in disulfoton production .

7.5.7 Wastewater treatment sludges in disulfoton production .

7.5.8 Wastewater from cleaning/stripping in phorate production .

7.5.9 Filter cake in diethylphosphorodithioic acid filtration in phorate production .

7.5.10 Wastewater treatment sludges in phorate production .

7.5.11 Wastewater treatment sludges in toxaphene production .

7.5.12 Distillation residue or heavy ends from tetrachlorobenzene distillation in 2,4,5 - T production .

7.5.13 2,6 - dichlorophenol wastes in 2,4 - D production .

7.5.14 Wastewater from vacuum stripper from chlorinator of chlordane in chlordane production .

7.5.15 Untreated wastewater in toxaphene production .

7.5.16 Untreated wastewater in 2,4-D production .

7.5.17 Wastewater in production of ethylenebisdithio carbamic acid and salt, including wash water supernates and filtrates.

7.5.18 Wastewater from reactor vent scrubber in ethylenebisdithiocarbamic acid and its salt production .

7.5.19 Materials derived from filtration, evaporation and centrifugation in ethylenebisdithio carbamic acid and its salt production .

7.5.20 Baghouse dust and floor sweeping dust from milling and packaging in production or formulation of ethylenebisdithio carbamic acid and its salt.

7.5.21 Wastewater from reactor and spent sulfuric acid from acid dryer in methyl bromide production .

7.5.22 Materials separated from wastewater and spent absorbents in methyl bromide production .

7.6 Production of explosives, i.e. wastewater treatment sludges from explosive production , spent carbons contaminated with explosive, wastewater treatment sludges from production, formulation or loading of initiating lead-based compounds and pink/red water from TNT preparation.

7.7 Petroleum refining industries, i.e. floats from dissolved air flotation (DAF) system, slop oil emulsions, tank bottoms contaminated with lead, sludges from API separator and sludges from heat exchange bundle.

7.8 Iron and steel production industry, i.e. wastes and dust from emission control in primary steel production using an electric furnace and spent pickle liquid from the steel finishing process arising in various production units.

7.9 Primary copper production industry, i.e. sludge and slurry blowdown in thickening in an acid plant.

7.10 Primary lead production industry, i.e. residues being in or scraped from surface impoundment in a smelting unit.

7.11 Primary zinc production industry, i.e. sludge or blowdown from an acid plant.

7.12 Primary aluminium production industry, i.e. spent potliners.

7.13 Secondary lead production industry, i.e. wastes and dust arising in production and spent solutions from leaching of wastes and dust derived from emission control with acid leaching.

7.14 Veterinary pharmaceuticals production industry, i.e. wastewater treatment sludges and distillation tars from distillation of aniline-based compounds and residues of activated carbon for decolorization in the production using arsenic or organo-arsenic compound.

7.15 Ink formulation industry, i.e. sludges and washes of solvents, caustic soda or water derived from cleaning tubs and equipment used in ink formulation from pigments, driers, soaps and stabilizers having chromium and lead as components.

7.16 Coking industry, i.e.

7.16.1 Ammonia still lime sludges from coking.

7.16.2 Tar sludges in decanter tank.

7.16.3 Residues from coal tar recovery , e.g. collecting sump residues in producing coke from coal or from recovery of coke by-products.

7.16.4 Tar storage tank residues in producing coke from coal or recovery of coke by-products.

7.16.5 Residues from light oil recovery , e.g. residues arising in stills, in decanters and in wash oil recovery units, which are in coke by-product. recovery .

7.16.6 Wastewater sump residues from light oil refining, including sludges from interception or contamination unit in coke by-product recovery .

7.16.7 Naphthalene collection and recovery residues in coke by-product recovery .

7.16.8 Tar storage tank residues in coal tar refining .

7.16.9 Coal tar distillation residues, including still bottoms.

7.17 Petrochemical industry, i.e. plastic products contaminated with solvents, plastic scrap arising from incomplete polymerization or contaminated with various types of solvents, wastewater treatment sludges contaminated with solvents or plastics of incomplete polymerization and surplus or spent catalysts and intermediates of all kinds.

Section 3

Wastes or Unusable Materials Having Characteristics and Properties of Unusable or Discarded chemical product, Off-specification species, Container Residues or Spill Residues

Article 8. Acute Hazardous chemicals.

8.1 Acetaldehyde, chloro-
8.2 Acetamide, N-(aminothiomethyl)-
8.3 Acetamide, 2-fluoro-
8.4 Acetic acid, fluoro-, (sodium salt)
8.5 1-Acetyl-2-thiourea
8.6 Acrolein
8.7 Aldicarb
8.8 Aldrin
8.9 Allyl alcohol
8.10 Aluminium phosphide
8.11 5-(Aminomethyl)-3-isoxazolol
8.12 4-Aminopyridine
8.13 Ammonium picrate
8.14 Ammonium vanadate
8.15 Argentate (1-), bis(cyano-C)-, potassium
8.16 Arsenic acid H_3AsO_4
8.17 Arsenic oxide As_2O_3
8.18 Arsenic oxide As_2O_5
8.19 Arsenic pentoxide
8.20 Arsenic trioxide
8.21 Arsine, diethyl-
8.22 Arsonous dichloride, phenyl-
8.23 Aziridine
8.24 Aziridine, 2-methyl-
8.25 Barium cyanide
8.26 Benzenamine, 4-chloro-
8.27 Benzenamine, 4-nitro-
8.28 Benzene, (chloromethyl)-
8.29 1, 2-Benzenadiol, 4-[1-hydroxy-2-(methylamino)ethyl]-
8.30 Benzeneethanamine, alpha, alpha-dimethyl-
8.31 Benzenethiol
8.32 2H-1-Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1-phenyl-butyl)- salt when present at concentration more than 0.3 %
8.33 Benzyl chloride
8.34 Beryllium powder
8.35 Bromoacetone
8.36 Brucine
8.37 2-Butanone, 3,3-dimethyl-1-(methylthio)-, O-[(methylamino)carbonyl] oxime
8.38 Calcium cyanide
8.39 Calcium cyanide $Ca(CN)_2$
8.40 Carbon disulfide
8.41 Carbonic dichloride
8.42 Chloroacetaldehyde
8.43 p-Chloroaniline
8.44 1-(o-Chlorophenyl)thiourea
8.45 3-Chloropropionitrile
8.46 Copper cyanide
8.47 Copper cyanide Cu(CN)
8.48 Cyanides (soluble cyanide salts)
8.49 Cyanogen
8.50 Cyanogen chloride
8.51 Cyanogen chloride (CN)Cl
8.52 2-Cyclohexyl-4, 6-dinitrophenol
8.53 Dichloromethyl ether
8.54 Dichlorophenylarsine
8.55 Dieldrin
8.56 Diethylarsine
8.57 Diethyl-p-nitrophenyl phosphate
8.58 O, O-Diethyl O-pyrazinyl phosphorothioate

APPENDIX L: SCECU ADMINISTRATOR'S MANUAL

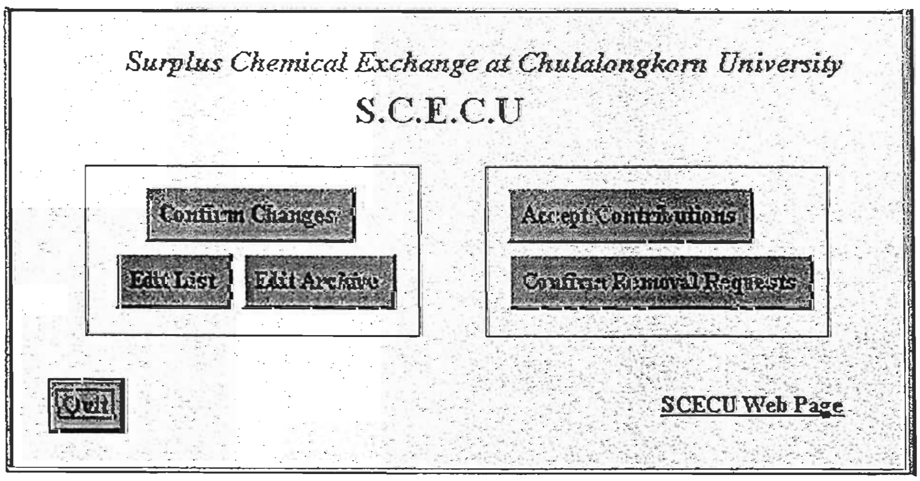
This document was made for use by the SCECU Administrator. It assumes that the reader has a thorough understanding of how SCECU functions, explaining only the basic operation of the computer components used for the online system. Major changes to the structure of these applications should not be performed without consultation with the network operators of the CU Chemistry Department.

The Microsoft Access 97 database has password protection to inhibit any tampering. Due to the way the database was set up, there is no need for a username to accompany the password. If the administrator opens the correct file and types in the current password of "SCECUAdmin", forms will guide the path further. Specific database details are contained in Table L-1.

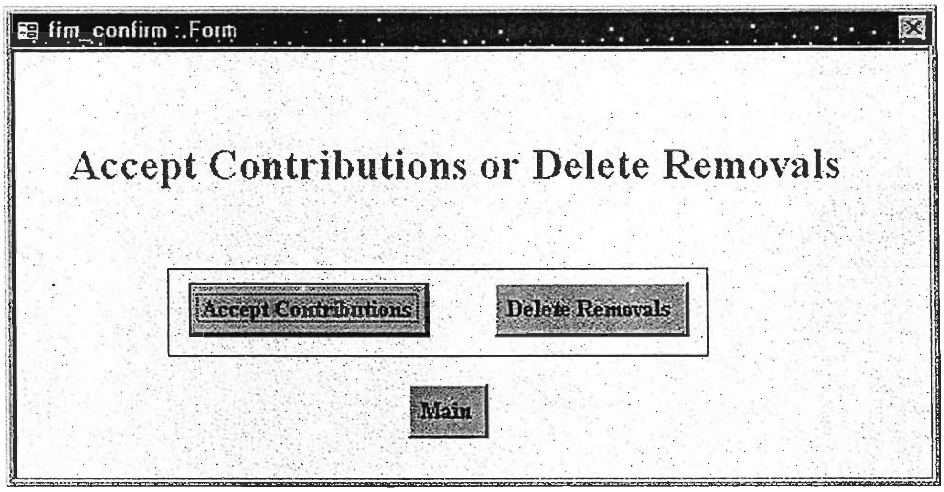
Table L-1: Database Details

Characteristic:	Detail:
Filename	SCECU.mdb
Path	c:\inetpub\wwwroot\SCECU\
Database Password	SCECUAdmin
ODBC Name	SCECU

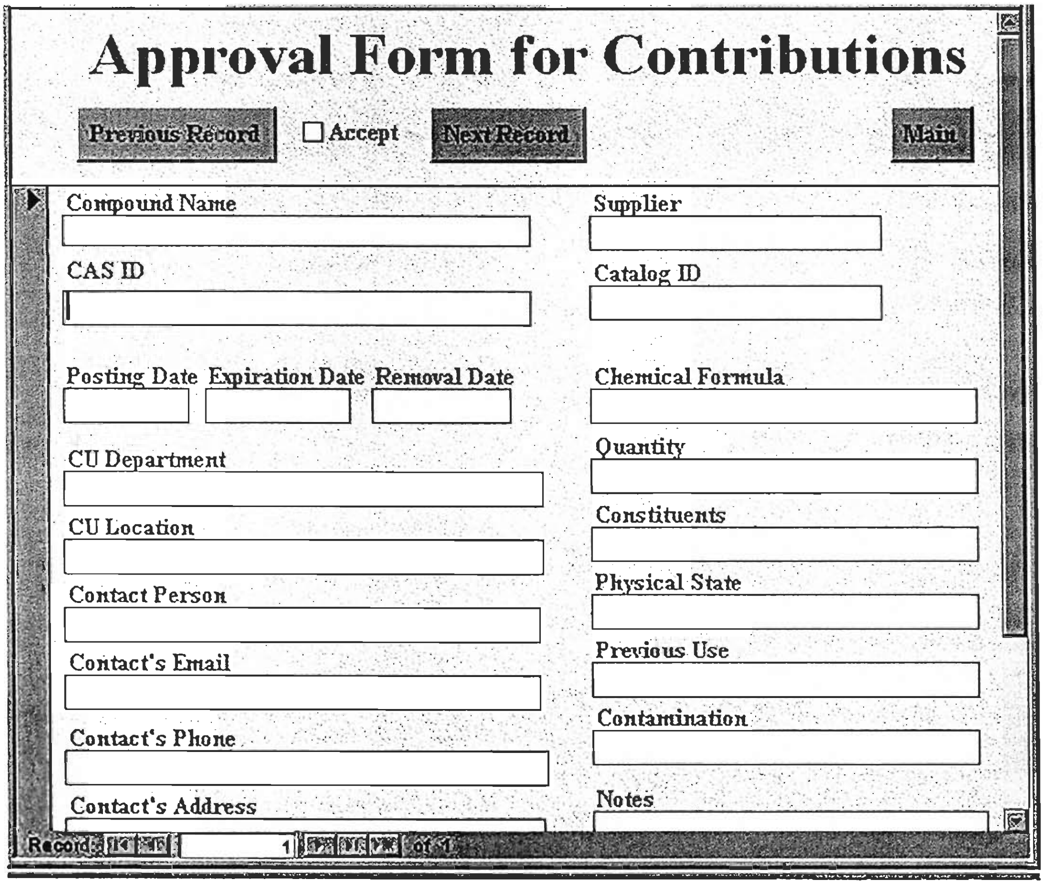
The main introductory form for the database appears below. There are five possible selections. It is possible for the manager to easily accept and reject changes made by Internet users.



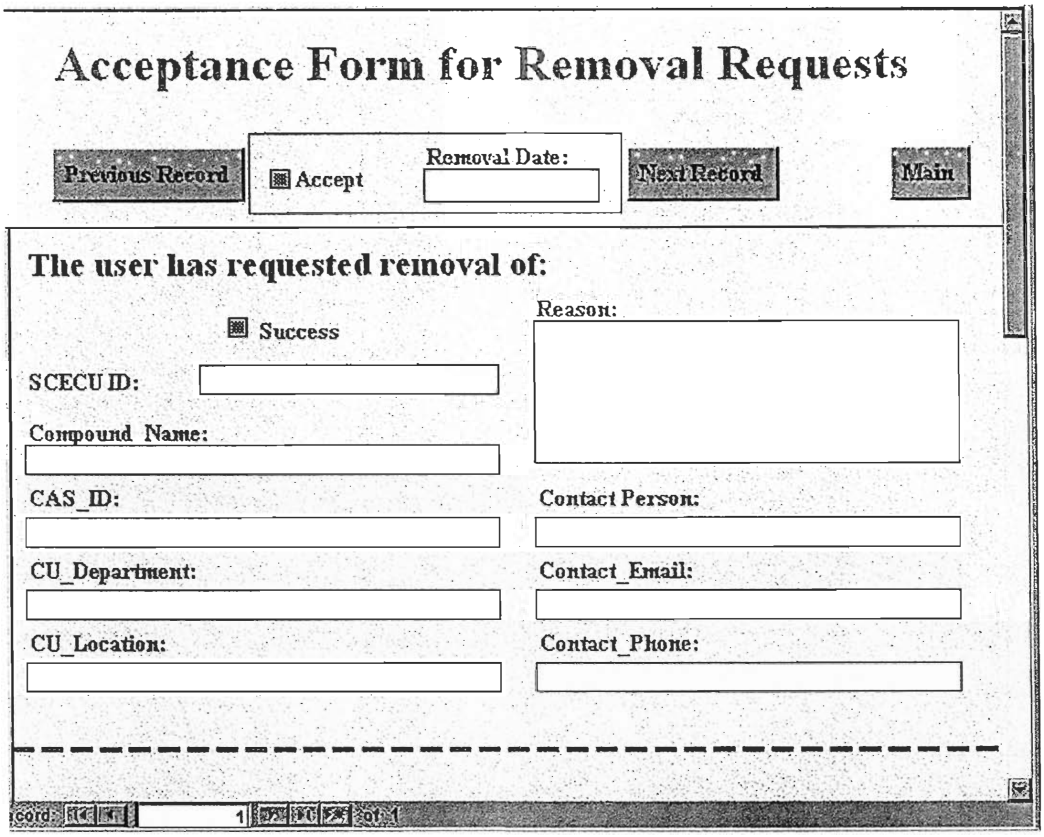
The confirm changes option brings up this screen. These buttons will run macros that execute a series of queries. The queries may pop-up dialog boxes asking you to confirm or deny record changes. You may choose *yes* for all of these. There is a menu setting in MS Access Tools | Options to turn them off.



The approval form used for contributions has one important item. The checkbox on the form header should be clicked each time a compound is accepted into the exchange. Afterwards, the *main* button can make the introductory menu reappear.



The acceptance form for removal requests behaves in a similar manner as described above. A donator can use the web to delete chemicals that he or she had previously added. The SCECU administrator will compare the records sent by the user with those in the actual list. If the manager decides to approve this request, the date of removal should be added. To finalize changes, the Accept form should be used.



To understand the internal layout of the database, there are a series of tables below that explicitly define the table, query, form, and macro names.

Table L-2: Database Tables

Tables	Function
tbl_list	List of shared chemicals
tbl_contribute	List of chemicals contributed over the web
tbl_remove	List of requests to remove successfully traded chemicals
tbl_archive	Auditing of previous transactions

Table L-3: Database Queries

Queries	Function
Qryapd_archive	Appends removed items to tbl_archive
Qryapd_list	Appends contributions to tbl_list
qrydel_contribute	Deletes contributions from tbl_contribute
qrydel_list	Deletes queries from tbl_list
qrydel_remove	Deletes queries from tbl_remove
Qryupd_list	Updates tbl_list
qry_removals	Compares data in tbl_remove and tbl_list

Table L-4: Database Forms

Forms	Function

frm_main	Choose menu options
frm_contribute	Approve contributions
frm_remove	Confirm removal requests
frm_confirm	Confirm changes to database made with other forms

Table L-5: Macros

Macro	Function
mac_add	Runs queries to add contributions
mac_remove	Runs queries to remove items from list
mac_openlist	Opens list table
mac_openarchive	Opens the archive table

Table L-6: Administrative Tasks

Administrative Tasks	Database Forms	Database Queries	Database Tables
Check Contributions	Frm_contribute		tbl_contribute
Approve Contributions	Frm_approve	qryapd_list qrydel_contribute	tbl_contribute tbl_list
Check Removals	Frm_remove	qry_removals	tbl_remove
Approve Removals	Frm_approve	qry_removals qryapd_archive qrydel_list qrydel_remove	tbl_remove tbl_list tbl_archive
Manage List			tbl_list tbl_archive

It may be necessary for the administrator to occasionally work inside the database itself. He or she may need to make changes to field names or the contents of queries. The data in fields such as phone or email could change often and new fields may have to be put in. Below is an example of tbl_list, the current listing of all shared chemicals. Great care should be taken to not damage any other data by accident.

Compound Name	Quantity
Formic acid	.75*1L
Lactic Acid	2.5x500m
1,2-Ethanedio (ethylene glycol)	3x1L
1,2-Propanedidiol	
2-Propanol	.75x2.5L
4-Methyl-2-pentanone	1x1L
iso-propyl alcohol	2x2.5L
propylene glycol	.5x500mL
antiseptic solution	4x1lb.
Benzensulsulfonyl chloride	1x500mL
Benzensulsulfonyl chloride	1x500mL
Bromobenzene	4x250mL
n-Butyl acetate	1x2.5L
Butylamine	1x1L
Cyclohexane	.25x1L
1,2-Dibromoethane	3.75x500r
1,4-Dioxane	1x2.5L
Dimethyl aniline	2x500mL
Dimethyl sulfoxide	.25x1L
Ethyl acetate	(1x2.5L)+(
Methyl acetate	3.75x500r
Nitrobenzene	3.75x1L
iso-Octane	1x2.5L

Table 1: Database Objects Related to Administrative Tasks

Some of the more the specific details concerning the SCECU web page database are shown in Table 7.

Table 2: Web Page Details

Characteristic:	Detail:
Web Site	http://www.chemistry.sc.chula.ac.th/SCECU/
Web Server	www.chemistry.sc.chula.ac.th
HTML File Path	C:\inetpub\wwwroot\SCECU\
ASP Script Path	C:\inetpub\scripts\SCECU\