

HOUSEHOLD HAZARDOUS WASTE:
AN ANALYSIS OF TWO
APPROACHES

By

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Scranton, Pennsylvania

1995

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December 1997

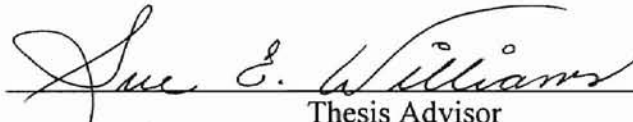
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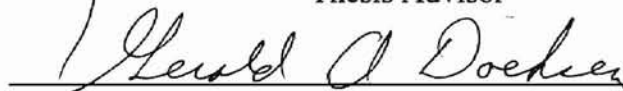
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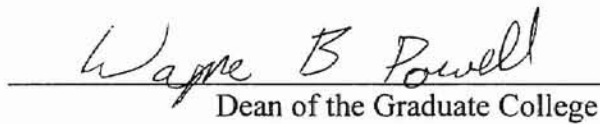
Thesis Approved:



Thesis Advisor







Dean of the Graduate College

ACKNOWLEDGMENTS

I would like to thank my committee members, Dr. Kay Bull and Dr. Gerald Doeksen for their interest and suggestions for this thesis. I extend sincere appreciation to my major advisor, Dr. Sue Williams for her support, and encouragement in all matters - academic and otherwise..

Special thanks to the M.e.t : Michael Patton, Terrie Hannam and Natalee Pendergraft for their help in finding needed information and sharing the ideas and data that made this thesis possible.

I wish to thank my parents and friends for their long standing support, interest and dedication to my endeavors. Their cheers from the east coast have made all the difference in the world.

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CHAPTER 1

INTRODUCTION

Background

Household Hazardous Waste (HHW) is defined by the Environmental Protection Agency (EPA) as a solid waste discarded from homes or similar sources, that are either hazardous wastes or wastes that exhibit any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity (40 CFR 261.3). Although HHW may cause harm to health and/or the environment if improperly discarded, EPA does not regulate HHW disposal (40 CFR 261.4). Products identified as HHW include, household cleaners and polishes, pesticides, drain openers, paint, batteries, hobby supplies, pool supplies, motor oil, and anti-freeze. These products when improperly used or disposed can cause cancer, birth defects, neurological and behavioral defects, kidney damage, lung and heart disease or acute poisoning (Bass, Calderon, Kahn, 1990). Efforts to keep HHW items from contaminating groundwater or leaching from landfills sparked the now common “household hazardous waste collection event.” Events are becoming increasingly popular as a means of removing HHW from the main municipal waste stream and ensuring proper disposal.

Typically, a community wishing to have a HHW collection event will hire a hazardous waste contractor who will be responsible for sorting, packing, transporting and disposing of the wastes. Events are usually one to two days in length and held in an easily accessible open area to allow for smooth traffic flow. Figure 1 shows a sample

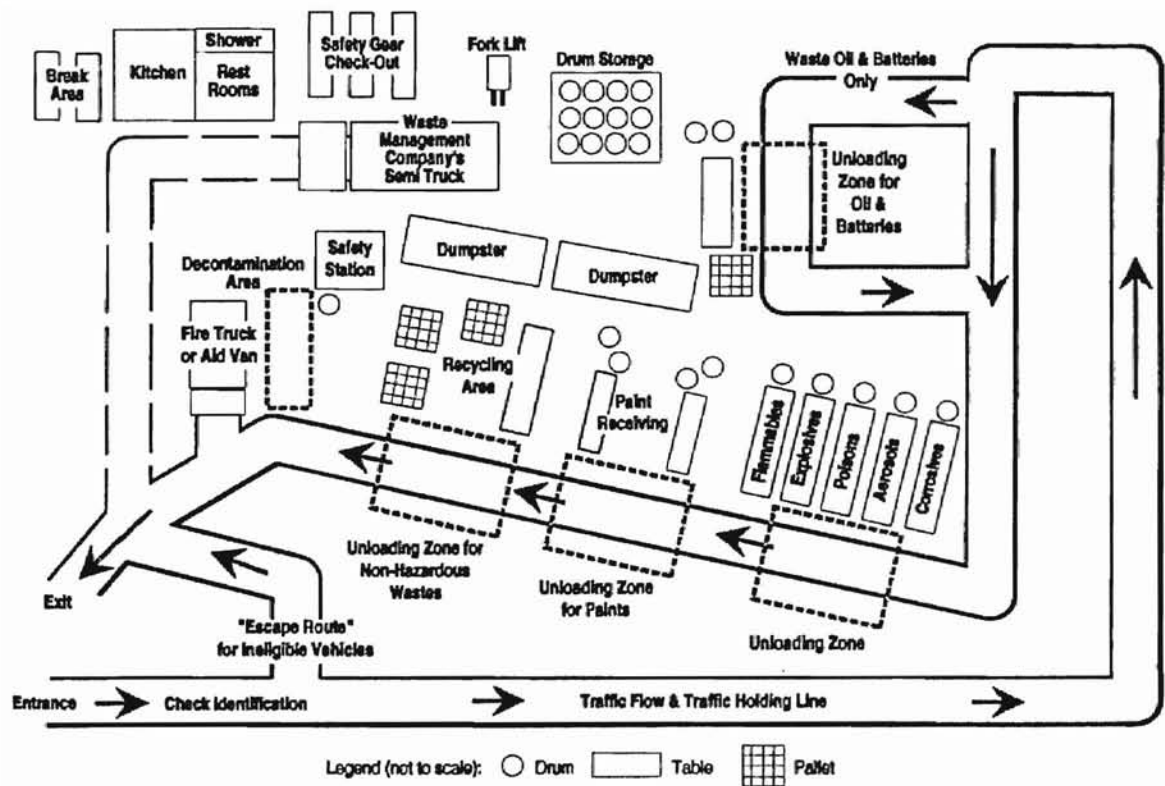


Figure 1. Household Hazardous Waste Collection Site Map (EPA, 1993)

traffic and set-up plan for a large scale HHW collection event (EPA, 1993). Wastes collected are recycled, incinerated, or landfilled depending on the type of waste and the safest method of disposal (Ruggeri, 1992). Table 1 shows some common categories of HHWs and potential disposal and recycling opportunities (Boyle & Baetz, 1993).

TABLE I
POTENTIAL DISPOSAL AND RECYCLING OPPORTUNITIES FOR HHW

Waste Type	Concern	Recycling and reuse	Treatment and disposal
Acids	Can react with other wastes, corrosive	Industries needing to neutralize high pH wastes. Consult waste exchange programs.	Neutralization, and possible landfilling of precipitates than can form as a result of neutralizing. May contain heavy metals.
Adhesives	Contain solvents	Difficult to recycle.	Incineration, or landfill after solidification.
Aerosol Containers	Explosive, flammable	Empty cans can be recycled with scrap metal.	Landfill.
Antifreeze	Toxic, may contain zinc or chromium	Easily recycled.	Incineration, biological treatment.
Asbestos	Can cause asbestosis if inhaled	Although it is easily recycled, markets are not easily available.	Landfill after treatment.
Batteries (Lead Acid)	Contain heavy metals	Plastic cases can be recycled, lead can be recycled.	Discharge neutralized acids, landfill plastic casing when recycling not possible.
Batteries (Dry Cell)	Contain heavy metals	Recycle.	Landfill.
Caustics	Corrosive, react violently with other chemicals	Possible reuse - consult waste exchange, neutralization of acids.	Landfill precipitate from neutralization.
Cleaners and Drain Openers	Can contain corrosives, solvents	Since it is a large mixture of various chemicals, reuse or recycling is unlikely.	Landfill, or possible incineration.
Fluorescent Fixtures & Hg Vapor Lights	Contain mercury vapor, may contain PCBs	Limited options.	Usual practice is landfilling with no prior treatment.
Fuels (Petroleum)	Contain benzene and other hydrocarbons	Can be burned as an energy source.	Incineration.

Waste Type	Concern	Recycling and reuse	Treatment and disposal
Lubricating Oil	May contain benzene and heavy metals	Widely recycled.	Incineration.
Oil Filters (Used)	May contain substantial amounts of used oil	Low recycling possibilities.	Incineration or oil extraction then landfill.
Paint (Water Based)	May contain heavy metals	Exchanges/swaps are common, recycling is possible.	Dry then landfill.
Paint (Solvent Based)	Contains solvents, may contain heavy metals	Reuse, possible recycling.	Dry then landfill.
Pesticides, Herbicides and Fertilizers	Toxic	Potential reuse, depending on fertilizer.	Incineration.
Pharmaceuticals	Toxic	Extreme liability.	Incineration, and possible composting.
Photochemical Products	May contain metals and organic compounds	Unlikely.	After treatment, discharge to waste stream.
Propane Tanks	Contain flammable residues	Refill, or recycle as scrap metal.	Landfill, when recycling is not possible.
Solvents (Non-chlorinated)	Toxic	Easily reused and recycled.	Incineration, do not landfill.
Solvents (Chlorinated)	Possibly carcinogenic	Can be recycled and reused as non-chlorinated solvents.	Incinerate at hazardous waste facility, do not landfill.
Smoke Detectors	Low-level radioactive material	Manufactures commonly reuse materials.	Follow requirements for radioactive materials.
Wood Preservatives	Toxic	Very few recycling possibilities.	Incineration, or landfill.
Other Wastes	Dependant upon property of material	Most cannot be recycled due to lack of market or products have since been banned.	Type dependant upon waste characteristics.

(Boyle and Baetz, 1993)

In 1994, there were 226 permanent collection programs in 30 states. From 1980 to 1994 there were 7,485 HHW collection events (Waste Watch Center, 1995). Figure 2 shows how this increase has taken place over the past years.

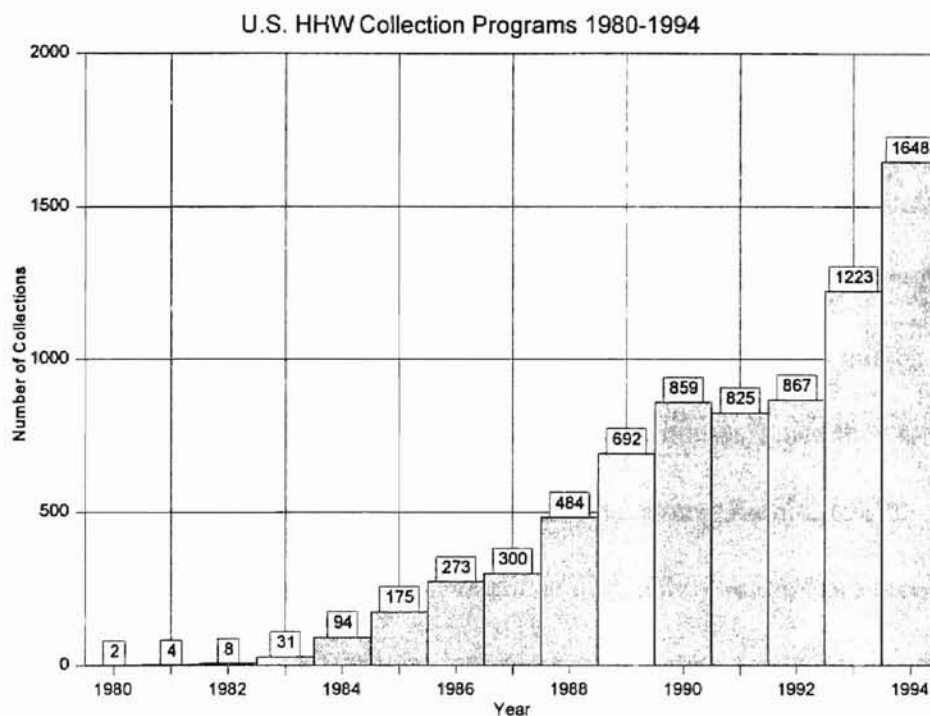


Figure 2. Total HHW Collection Programs (Waste Watch Center, 1995)

It is obvious that HHW collection events are becoming a popular way of handling hazardous waste generated from homes. The management of household hazardous waste collection events and permanent facilities has received some attention in the literature. Training manuals devoted to managing a collection as well as success stories about collection techniques are common. Despite the available material, several important issues about household hazardous waste remain neglected.

Purpose of the Study

The intent of this study is to provide two pieces of practical information.

Household Hazardous Waste (HHW) management is an issue of concern to many cities and local governments because HHW programs are expensive and require substantial planning. To better help in the planning of HHW events or collection facilities, this study will attempt to understand the costs associated with two common collection options available to most communities today: the semi-annual collection event and the permanent collection facility. This study identifies many of the unanswered questions about HHW. HHW is difficult to characterize because of its diverse nature. It is a challenge to describe the types and quantities found in homes, since they will vary greatly in quantity and type across geographic regions (Wilson and Rathje, 1989). While countless reports of the toxicity of HHW are available they seldom produce the needed information to ensure that HHWs are indeed worthy of their treatment as a hazardous waste. They provide little substantial information about the actual toxicity of the products. This study will identify current approaches to determining HHW toxicity and further discuss the critical HHW information lacking from the current literature as well as describe the benefits of obtaining this information.

CHAPTER II

REVIEW OF LITERATURE

Most literature pertaining to Household Hazardous Waste (HHW) falls into one of three main categories: Household Hazardous Waste Management, Public Awareness, and Toxicity. The following is a detailed discussion of the current literature on each topic. In addition, a fourth category titled Risk Related Issues explains how risk and risk perceptions are integrated into HHW issues.

Household Hazardous Waste Management

Despite their great cost, HHW collection events are becoming increasingly popular across the United States and in Europe. Since 1981 the number of collections in the U.S. has almost doubled. Also, the number of permanent collection facilities is on the rise (Waste Watch Center, 1995). Figure 3 shows the locations of permanent facilities in the United States. This may be an indication that HHW collections are not just an environmental trend rather, they are becoming a way of life in many communities like plastics and aluminum recycling facilities. Unfortunately, the nature of HHW collection events require trained personnel and the ability to accept various types of wastes, some with special disposal requirements. In order to meet these needs, collection events often cost as much as \$100 per car (Dann, 1995). Some events have totaled approximately \$70,000 for a 1-2 day event. For this reason, the funding of HHW events has become controversial. In many cases small communities are at a disadvantage due to the high

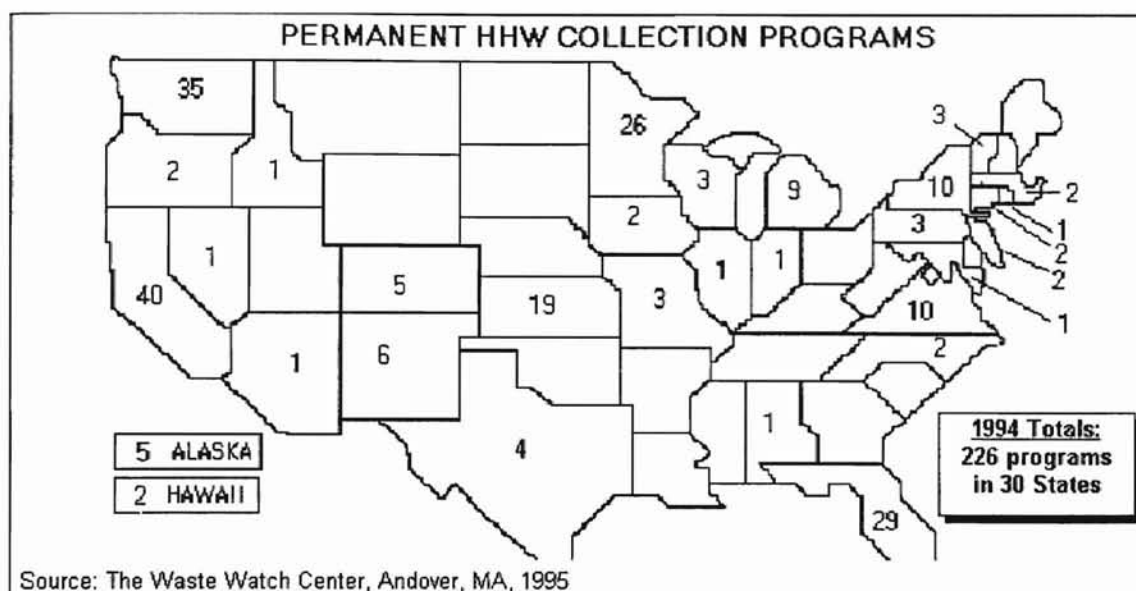


Fig 3. Locations of Permanent HHW Collection Facilities.

cost of the collection. Larger cities are more likely to have the needed resources to sponsor a collection event, whereas small communities need their resources for other community programs.

Household Hazardous Waste collections are voluntary programs that vary in their frequency and the type of wastes that are collected throughout the country. For example, a small collection in New York state, is run by a private company and saves the city thousands of dollars in cost (Ruggeri, 1992). Two thousand six-hundred vehicles participated in the event. The private sponsorship saved the city between \$50,000 and \$100,000. In contrast, Oregon combines their HHW collection with a comprehensive recycling effort that targets everything from plastics recycling to composting and is funded through city budgets (Perry, 1996). Their goal was to reduce the overall size of

their landfill due to a lack of space. The savings in landfill tipping fees is now used to partially fund the program. The HHW portion now consists of two permanent sites in addition to a mobile unit that traverses the outlying counties. The permanent facilities served 21,000 customers in 1995 (Perry, 1996). The program succeeded in reducing the overall quantity of wastes sent to the landfill and boasts a 41% overall recycling rate (Perry, 1996). While these cases represent the innovative and creative side to HHW collection many communities support HHW events without the generosity of private companies or the success of Oregon's program. Compliance rates of 0.2-1% of eligible households are not uncommon (Scudder & Blehm, 1991; EPA, 1993). This creates an ironic situation: greater compliance may in some cases, make a HHW event cost prohibitive.

A recent study by Anex (1995), states that HHW events may not be beneficial in terms of cost. A travel cost analysis was performed for HHW sites in King County, Washington. The total cost for 26 collections held during a year was \$1.6 million while the estimated consumer surplus based on the travel-cost evaluation was \$95,396. It was estimated that residents were willing to pay \$6.50 per household for the service while the actual cost of disposal is \$73 per household. Unfortunately this study did not take the added landfill space or the environmental effects into consideration. A study by Niemeyer (1996) found a similar discrepancy. Citizens were willing to pay much less than the actual cost of a collection.

One other consideration to the economic feasibility of HHW collections is that like many other businesses, more expenses are incurred in the first year than in subsequent years. In some cases, collection costs have been reduced from \$70 to \$50 per

car load after the collection process has been refined (Dann, 1995). Also, many cities are moving towards establishing permanent collection facilities and/or door-to-door pick-ups of HHWs (Dann, 1995).

Besides evaluating the cost effectiveness of a HHW collection program, the applicable federal regulations must be considered. Although HHW are not regulated by the EPA as a hazardous waste, there are still many regulations that relate to collection events. Table II shows the applicable federal regulations and agencies that affect collection events.

TABLE II
APPLICABLE FEDERAL REGULATIONS FOR HHW COLLECTION EVENTS

Regulations	Location in Code of Federal Regulations	Concerns for HHW Collections
Resource Conservation and Recovery Act (RCRA)	40 CFR 260	Households and CESQG's are exempt. All others are subject to some form of regulation.
Comprehensive Environmental Response Compensation and Liability Act (CERCLA)	42 CFR 9601	No source is exempt from liability of clean-up costs.
Toxic Substances Control Act (TSCA)	40 CFR 700	Contains regulations for PCB's and asbestos.
Occupational Safety and Health Act (OSHA)	29 CFR 1910	Contains regulations for employee working conditions and training requirements for working with hazardous substances.
Department Of Transportation Hazardous Materials and Waste Transportation Regulations	49 CFR 171	Contains regulations for transporting hazardous materials and wastes.

The most important guideline for HHW collections under the Resource Conservation and Recovery Act (RCRA) is the definition of a household waste in 40 CFR 261.4 (b)(1) (EPA, 1993). To be a household waste, the waste must be generated by an individual on the premises of the household and the waste must be composed primarily of wastes generated by consumers in their homes. Under RCRA, a hazardous waste landfill or collection site is required to obtain a permit. However, a HHW collection does not need a permit to collect household wastes. This exemption applies to household waste through its entire life. This means household waste is exempt from the time it becomes a waste to its disposal. Many HHW collection programs accept wastes from Conditionally Exempt Small Quantity Generators (CESQG). A CESQG produces less than 100 kg of hazardous waste per month (Waste Watch Center, 1995). CESQGs are responsible for making sure that their waste is managed according to federal requirements

Appropriately, the collection should provide the CESQG with documentation that the waste has been properly disposed. CESQGs should not be confused with Small Quantity Generators (SQG). SQGs generate 100 kg to 1,000 kg of hazardous waste per month. They are required by federal law to follow specific packaging requirements and use manifest forms for shipping their waste. They are not exempt from federal regulations therefore, a HHW collection may not accept waste from a SQG unless the collection has obtained a RCRA Subtitle C permit (EPA, 1993). Thus, it is necessary to teach workers at the collection the differences between a CESQG and a SQG. Many collections avoid this problem by requiring CESQGs to pre-register for the collection. This gives the collection time to inquire about the quantity and type of waste the CESQG wishes to bring (EPA, 1993).

The Comprehensive Environmental Response Compensation and Liability Act (CERCLA) addresses the cleanup of hazardous waste sites. CERCLA does not exempt HHW collections from liability for cleanup of contaminated sites. "The Agency [EPA], however will generally not notify generators or transporters of municipal solid waste - including HHW collection programs - that they are considered PRP's [Potentially Responsible Party] *unless* EPA has information indicating that the waste came from an industrial, institutional, or commercial process or activity" (EPA, 1993). This provides excellent motivation for collection organizers to screen industrial wastes from their collection.

The regulations governed by the Toxic Substances Control Act (TSCA), Occupational Safety and Health Act (OSHA), and Department of Transportation (DOT) are essential for organizers wishing to collect HHWs without the help of a hired contractor who will package, transport, store and dispose of collected wastes. If the organizer is determining the fate of all wastes, it is essential that they become familiar with rules and regulations under the DOT and TSCA. Under TSCA, consolidated oil based paint must be tested for polychlorinated biphenyls (PCBs) before it is sent to a fuel-burning facility. Paint that contains more than 50 ppm PCBs must be sent to a facility permitted to burn PCBs (EPA, 1993). If a contractor will be packaging all wastes, it is necessary for the organizer to determine what types of wastes the contractor will accept for disposal. For example, many contractors will not accept radioactive materials (Waste Watch Center, 1995). The organizer must have a plan to dispose of all materials brought to the collection. In addition, proper disposal of radioactive substances, or chemicals

such as PCBs may be expensive. Transportation requirements for radioactive substances and PCBs should also be considered before accepting these wastes.

OSHA requires training for employees working with hazardous materials. According to 29 CFR 1910, the toxic and hazardous substances standards, hazard communication standard, hazardous waste operations and emergency response and injury and illness prevention programs are of concern for HHW programs (Waste Watch Center, 1995). OSHA also sets training standards for employees depending on the level of hazard to which they are likely to be exposed. These standards also apply to volunteers and municipal employees. Most collection organizers will hire a contractor to pack, treat, store and dispose of the collected household wastes. This will eliminate many of the concerns over OSHA, DOT and TSCA regulations. Contractors typically provide trained personnel to package HHWs and they become responsible for transportation and final disposal of the waste.

Training requirements will vary according to the role of volunteers and contracted employees. State laws may be applicable to training requirements. Depending on the staff of the contractor, only minimal training may be required for volunteers and persons hired by the collection organizer. Since contractor staffing may be expensive, it may be more efficient to hire local city or town employees with appropriate OSHA training to work in areas where they will have direct contact with wastes. This way, the organizer will only need to train volunteers and other workers who will have limited exposure to the wastes.

Public Awareness

In an effort to characterize both Household Hazardous Waste (HHW) and the average knowledge of a consumer about HHW, several studies of public awareness have been performed. Unfortunately, most have come to the conclusion that consumers do not fully understand the risks associated with HHW. This is a grim finding since 1997 studies reveal the same general findings as studies done in 1990 (Bass et al., 1990; Wolf, Kettler, Leahy, Spitz, 1997). When one considers the increase in HHW collections across the country and that the first collection was held in 1981, it is clear that education about HHW should be a top priority for the future.

One frequently addressed problem in the literature is the lack of knowledge among consumers about Household Hazardous Products (HHP). Many communities with well established collection programs still report that community members are not aware of collection services or do not feel they are necessary (Wolf et al., 1997; McEvoy & Rossignol, 1993). Many reports have cited that consumers are not aware of the dangers that household products may pose to themselves or the environment (Wolf et al., 1997). Changing the attitude of consumers may help improve community participation at HHW collection events.

Extensive research has been performed to characterize the type of person who attends collection events and their perception of the relative hazard of household chemicals. Most studies concur that the average consumer knows little about the toxicity of household products and does not consider them dangerous (McEvoy & Rossignol, 1993). Consumers also report that they do not consider the environmental impacts of many household products when purchasing, using or disposing of them (McEvoy &

Rossignol, 1993; Bass et al., 1990; Scudder & Blehm, 1991). Even in areas with established collection events many residents of the community do not know of the existence of the collection event or do not take advantage of the service (Wolf et al., 1997). Unfortunately, some cities have found that there is an increase in less desirable disposal practices after a collection event (Freshwater Foundation, 1988). By educating people about the danger of having HHWs in their homes, many homeowners have a tendency to purge their home of HHWs even though they did not make it to the collection event. This results in improper or illegal disposal of HHWs in dumps and/ or down municipal sewer lines. This, in turn, can harm a water treatment facility and render it unable to properly treat water if HHWs are disposed of in large enough quantities (McEvoy & Rossignol, 1993).

Surveys of homeowners found that most paints and pesticides are disposed improperly and most are sent to landfills. Of the people surveyed, wastes were sent to municipal landfills, down sewers and poured on the ground (Bass et al., 1990). Twenty eight percent of the people surveyed could only name one product in their house that was hazardous, 12% could not name any hazardous products and over 40% could name more than one product (Bass et al., 1990). Bass also states that toxic substances require special treatment beyond placement in a municipal landfill because of the possibility that soil and water can become contaminated with chemicals. Household hazardous wastes can also cause problems for sewer treatment plants. In addition, Bass states that the problem of cumulative effect is foreign to most people and therefore fuels the difficulty in understanding the dilemma. Homeowners do not conceptualize their small amount of

waste as part of the large accumulation of wastes in landfills, or that the chemicals in their products become more toxic when mixed with chemicals from other products.

A survey performed by McEvoy and Rossignol (1993) found that the majority of those surveyed used improper disposal methods with the exception of motor oil. They state that one possible cause for the lack of proper disposal is that people do not consider household wastes as hazardous. Also inaccessibility to collections may cause some improper disposal. A survey by Niemeyer (1996) states that most of the Nebraska residents surveyed placed their household wastes in the trash, poured them on the ground or took them to a landfill. Also, Niemeyer found that many residents chose to store their household hazardous wastes because they did not know how to dispose of them.

A report by Scudder and Blehm (1991) found that 40% of people surveyed were not aware that household chemicals could pose a danger to themselves or the environment. They also report no motivation to improve the situation. Those surveyed believe that hazardous waste is a problem for government and business. The researchers believe that increased awareness and the stressed role of the household could make an impact and raise levels of awareness significantly.

The most recent characterization study by Wolf et al. (1997) found that people used up only 62% of the paint they purchased, 89% of their pesticides and fertilizers and 90% of their cleaners but only 46% of their automotive products. Of those surveyed 31% did not believe or know that household hazardous wastes could cause health problems and 24% did not believe or know that HHW could cause environmental damage. They also report that the motivation to use existing safe disposal methods, such as a collection were low.

Toxicity

The toxicity of Household Hazardous Waste (HHW) is discussed in two separate areas. HHW has become a concern both during usage and disposal. These two areas present separate problems and require separate management techniques.

Toxicity in the Home

Household Hazardous Products (HHPs) are a concern for the consumer because some consumer products may pose a threat to human health (McEvoy & Rossignol, 1993). Products considered HHPs are sometimes cited as a threat to indoor air quality (IAQ). Since IAQ is still being extensively researched, the exact impact of HHW in IAQ is not yet fully understood. EPA's Total Exposure Assessment Methodology (TEAM) studies, developed in 1979, measure levels of contaminants in the home. One principal finding from these studies is that exposures to toxic volatile organic compounds is not significantly affected by a person's proximity to a chemical plant or petroleum refinery (Wallace, 1993). The TEAM studies have also identified some products considered to be HHW as increasing the levels of chemicals found in indoor air. However, other sources of contaminants such as gas stoves may be the most significant forms of indoor pollution (Smith, 1993; Wallace, 1993).

Educational materials on HHW often focus their attention to reading product labels so consumers can make decisions about products before they bring them into their homes. This is usually accomplished through recognition of signal words and symbols on product labels. The Consumer Product Safety Commission (CPSC) controls the labeling requirements for household chemicals. The rules and guidelines for determining product classifications are located in the Code of Federal Regulations Part 16, Subchapter

C. The guidelines are based on the acute toxicity of products that meet the CPSC's definition of "hazardous." A substance is hazardous according to the CPSC if it is toxic, corrosive, or flammable and can cause substantial injury or illness as a result of normal use (16 CFR 1500.3). While the guidelines are based on the amount of risk they pose to human health, they are not mandatory, do not consider risk to the environment and do not consider their effectiveness in communicating the risk the product poses.

The CPSC regulations for hazardous products intended or packaged for household use or for children are based on the toxicity of the product. The CPSC defines toxic as any substance which has the capacity to produce personal injury or illness to man through ingestion, inhalation or absorption through any body surface (16 CFR 1500.3). The guidelines are specifically for determination of acute toxicity and do not consider chronic effects. As of October 9, 1992, specific guidelines became mandatory for art supplies and art products. The same guidelines are suggested for all other hazardous household products but are not required. It is the responsibility of the manufacturer to determine the toxicity of the product and label the package according to the CPSC's guidelines. Any products not labeled correctly are considered "mis-branded" in violation of the Poison Prevention Packaging Act of 1970 (16 CFR 1500.3).

CPSC suggests calculating risk for three routes of exposure: inhalation, dermal contact and oral ingestion. While human studies are preferred, animal data are often the only method of testing. When specific populations are at risk, like pregnant women, the information must be noted on the product label. The CPSC sets an acceptable risk level of products at 1 in a million deaths during a person's lifetime.

For a substance to require labeling (to be considered hazardous) it must have the potential to be both toxic and "cause substantial personal injury or illness during or as a proximate result of any customary or reasonably foreseeable handling or use, including reasonable foreseeable ingestion by children" (16 CFR 1500.3(a)). Manufacturers must consider the amount of toxic substance in the product, bioavailability, and exposure when making their toxicity determination. Products are then categorized as either highly toxic, acutely toxic or chronically toxic depending on the results of the laboratory tests.

While the CPSC's guidelines are only for acute toxicity of household products, they require that toxicity assessments include chronic effects because the "current scientific knowledge concerning chronic hazards is insufficient to allow the guidelines to specify criteria that can be mechanically applied to determine if a product is toxic" (FR 46633). Determination of chronic toxicity will require assumptions and expert knowledge for specific situations. After testing, products are classified as highly toxic, acutely toxic or chronically toxic.

The warnings of product labels are required to provide certain information about product safety, disposal, and use. Their purpose is to provide language that helps to explain the risk associated with the product to the consumer. Once the toxicity of a product has been determined, the package must be labeled according to the regulations in 16 CFR 1500. The basic label requirements state that all products should have:

1. the name and place of business of the manufacturer, packer, seller or distributor;
2. the common name of the hazardous substances or each component that contributes substantially to the hazard;
3. signal word;
4. a statement of the principal hazard that is descriptive of the hazard;
5. action to be followed when using the product;

6. instructions for first aid;
7. the word POISON and DANGER on any product that is "highly toxic";
8. storage and handling requirements;
9. and the statement "Keep Out of Reach of Children", and DANGER on flammable or corrosive products.
10. the word CAUTION or WARNING on all other hazardous substances.

When a product poses both a chronic and an acute hazard the word for the acute hazard must be used. If the product only poses a chronic hazard, the label must bear the word WARNING. Other chronic hazard statements should be added when appropriate such as "May be Harmful by Breathing Vapors/Dust" or "May be Harmful if Swallowed." Precautionary statements such as "Store in a Well Ventilated Area" or "Wash Hands Immediately After Use" are required for safe handling instructions but no guidelines for assigning these labels are provided. Special considerations exist only for diethylene glycol, ethylene glycol, benzene, toluene, xylene, petroleum distillates, methyl alcohol, turpentine and charcoal. These products are required to have special labels because the CPSC has determined that the standard labeling requirements were not sufficient to protect human health (16 CFR 1500.126).

Environmental Toxicity

Household Hazardous Waste can be a detriment to the environment. Of particular concern is the toxicity of products found in municipal landfills. Studies have shown that leachate from municipal landfills with no history of accepting hazardous or industrial wastes have leachate toxicity levels greater or equal to that of Love Canal (Schrab, Brown, Donnelly, 1993). One possible reason for the high toxicity of these landfills is HHW. The burning of household products is also a method of contaminating the

environment, threatening water quality and potentially causing human injury. Because some of these products are reactive, when mixed with other products, there is the potential for dangerous reactions that have caused injuries to sanitation workers (Williams & Duxbury, 1982).

A report by Karpinski and Glaub (1994) cites 10 chemicals found in municipal solid waste landfill leachate at levels above EPA's drinking water standard. They show that the overall composition of landfill gasses from hazardous and non-hazardous waste landfills are similar with no major distinguishing factors. Education about consumer products is one step in the landfill screening process to keep harmful chemicals out (Karpinski & Glaub, 1994). Table III shows the 10 chemicals studied and their potential use in household products.

TABLE III
POTENTIAL HOUSEHOLD USES OF CHEMICALS FOUND IN NON-
HAZARDOUS AND HAZARDOUS WASTE LANDFILLS

Chemical	Potential Products Containing Chemical
Benzene	Dry Cleaning Fluids, Fumigants, Gasoline, Insecticides, Motor Oil, Paint Remover, Rubber Cement, Solvents (various), Spot Removers
Carbon Tetrachloride	Degreasers, Fumigants, Propellants, Refrigerants, Solvents (various)
Chloroform	Anesthetics, Fluorocarbon Refrigerants, Fumigants, Insecticides, Pharmaceuticals, Solvents (various)
1,2-Dichloroethane	Degreasers, Finish Removers, Fumigants, Gasoline, Paint Removers, Penetrating Agents, Scouring Compounds, Soaps, Solvents (various), Wetting Agents
Ethylene Dibromide	Fumigants, Gasoline, Solvents (various), Waterproofing Preparations
Methylene Chloride	Aerosol Propellant, Degreasers, Dewaxers, Fumigants, Furniture Refinishers, Hair Spray, Oven Cleaner, Paint, Paint Brush Cleaner, Paint Remover, Septic Tank Cleaner, Shoe Cleaner, Shoe Polish, Solvents (various), Suede Renewer
Tetrachloroethylene	Degreasers, Dry Cleaning Solvents, Drying Agents, Heat Transfer Medium, Paint Removers, Spot Removers
1,1,1-Trichloroethane	Aerosol Propellant, Degreasers, Drain Openers, Furniture Polish, Oven Cleaner, Paint Remover, Pesticides, Rug Cleaner, Septic Tank Cleaner, Shoe Dye, Shoe Polish, Solvents (various), Spot Remover, Upholstery Cleaner
Trichloroethylene	Adhesives, Degreasers, Dry Cleaning Fluids, Dyes (solvent-based), Fumigants, Fur Cleaner, Paint, Pharmaceuticals, Shoe Cleaner, Shoe Polish, Solvents (various)
Vinyl Chloride	Adhesives for Plastics, Intermediate in Polymer Production

(Karpinski & Glaub, 1994)

In addition to landfill contamination, HHW is also of concern to municipal water treatment plants. Municipally treated water often is cited as a potentially targeted effect of HHWs. Reports of household chemicals being present in large enough quantities to kill the microorganisms at a municipal treatment plant are cause for concern in many communities (Bass et al., 1990). In an effort to better understand which types of wastes are acceptable for landfilling, and which should be diverted, Gapinski (1988) proposed a model to assess the impact of HHW on landfill leachate. The model attempted to determine the amount of a particular chemical to be disposed in order to exceed drinking water standards. Unfortunately for the model to be successful, a database of the form and relative quantity of contaminants in a particular HHW are needed. In addition, the exact components and weight fractions of each category of HHW are needed. For example, the types of products and chemicals that make up the pesticide and lawn care product category must be identified (Gapinski, 1988). Illegal dumping of HHP may also affect water quality, probably more significantly than water sent to a treatment plant. Pouring household chemicals directly on to the ground or down a storm sewer may cause environmental damage, as this water is not treated by any man made system before reaching the environment.

According to the Soap and Detergent Association (SDA), current chemical assessment methods protect human health and the environment (Sedlak, 1996). The SDA believes that chemical-by-chemical risk assessments are adequate to protect human health and the environment. Sedlak (1996) states that the chemical-by-chemical assessment method gives manufacturers an accurate account of the effect a product will have when it reaches the environment. The SDA states that if the concentration in an

environment is less than what would cause a detrimental effect to the organisms living there, there is no detrimental effect (Sedlak, 1996). Using the chemical-by-chemical testing method may not be appropriate for household chemicals since they are used in an environment where they can be mixed with other products. The SDA does not consider the reaction of a product with other chemicals in a landfill or waste water system. The Soap and Detergent Association estimates concentrations entering the environment using models. They do not state if these models consider the variations of chemical quantities and type with seasons and geographical area. The growing concern over residential issues such as indoor air quality and municipal waste demonstrate that there is a need to look at the cumulative effects of chemicals (Zummo & Karol, 1996; Schrab et al., 1993). Continuing to look at products on a chemical-by-chemical basis does not help solve these problems.

The SDA method does determine environmental risk which is not required by the CPSC. There is evidence of the high toxicity of municipal landfills where most hazardous household products are disposed. Municipal landfills have been found to be just as toxic as hazardous waste landfills (Schrab et al., 1993). While these wastes can pose an individual threat to human health and the environment, the cumulative effect of these wastes may be more threatening.

Risk Related Issues

It is clear from the numerous HHW surveys already discussed that consumers do not have a complete understanding of the dangers associated with HHW. A study performed by Shorten, Glowacki and Lynch (1995) found a difference in the way the

health effects of various automotive products were perceived. Home mechanics and non-mechanics were surveyed. Both groups perceived automotive products as posing a significant health risk. Although there was not a difference in the risk perception of automotive products in general, specific products were seen as more harmful than others. Motor oil was perceived to be less harmful than other automotive products. Risk perceptions are known to be affected by the familiarity of an event (Slovic, 1987). Familiar activities are often perceived as less risky than those that are less familiar. People are also less likely to perceive an activity as high risk if it is voluntary, such as purchasing household products. Applying the concepts of mental modeling to HHW may lead to a heightened awareness and better educational tools in the future.

Product Labeling

The current labeling standards for household products may also play a role in how HHP are perceived. A study performed to determine the effectiveness of product label warnings tested four sets of consumer labels each with increasing amounts of risk information (Viscusi & Magat, 1987). One label contained no risk information, two contained the legal requirements of the CPSC - one of which was more prominently displayed than the other, and a label with extensive, prominently placed risk information. The study found that after reading only the legally required information, most participants did not know the risks associated with the product. After reading the labels with the most product information, participants were better able to understand the product's risks (Viscusi & Magat, 1987).

The study by Viscusi and Magat set out to accomplish five specific goals: to motivate the consumer to read the label, to make the label easy to understand, to make the label easy to compare with other products, to make the safe usage information easy to understand, and to enable the user to take appropriate action if the product is mis-used. The most effective label contained detailed risk information prominently displayed on the label. The study shows that the methods of communicating risk information may not be appropriate for the types of risk posed by household hazardous products. While the CPSC requires that label safety information be a specific size and in certain proportions on the label, Viscusi and Magat have shown that placement beyond what is required by the CPSC is necessary to teach people about the risks of the chemical products they use (1987).

Consumers process information in the manner in which it is presented (Viscusi and Magat, 1987). This means that a consumer will understand the information presented on the label by the way that it is arranged. Therefore, the placement of hazard information is critical to the consumer's understanding of a product's risks. The labeling study also demonstrated that placing certain pieces of information in the same place on the label consistently lead to greater recall by the consumer. Providing a standard for all product labels would increase the level of understanding by the consumer. By allowing companies to manipulate label information, they can disguise the required risk information and make other positive product attributes more salient.

Other studies have found that most consumers do not understand the risks associated with household chemicals (Bass et al., 1990). Many HHW collection surveys have identified that people do not understand the hazards associated with the products

they use (Bass et al., 1990). This may be sufficient evidence to determine that products labels do not provide enough information for the consumer to make educated decisions about the risks posed by the products they bring into their home. Most consumers assume that since a product is sold, it poses no significant risk to the general public. Product labeling adds to this confusion. Labels that follow only the guidelines set by the Consumer Product Safety Commission, did not succeed in conveying the appropriate hazard and warning information as did more explicitly labeled products (Viscusi and Magat, 1987).

Consumer Risk Perception and HHW

To date, most of the literature about HHW discusses the lack of understanding on the part of consumers about HHW issues. Studies have examined HHW awareness in both areas with collection events and areas without them. The overwhelming result of these studies concludes that people remain unaware of the risks posed by HHW. In addition, the risks posed by HHW remain unconfirmed and unquantifiable. This not only provides an explanation for the lack of consumer awareness about HHW but it explains what pieces of information are needed to make any improvements in HHW awareness.

Studies attempting to characterize consumers and their knowledge of HHW have provided some interesting insights into HHW and currently unaddressed issues. People living in rural areas are more likely to be satisfied with current disposal methods such as burning and less likely to support collection programs than those living in urban or metro areas (Niemeyer, 1996). With instances of illegal dumping in rural areas, it is likely that significant contamination of the environment can occur if these practices continue

(Fitzgibbon et al., 1995). Issues in rural areas are also problematic since these areas are less likely to have a collection event. Many educational materials suggest consumers takes HHPs to a collection event but do not offer other disposal alternatives when a collection event is not available (Niemeyer, 1996).

A study by Scudder and Blehm (1991) found that only 25% of the survey group could name four or more hazardous products and another 25% could not name any. Sixty-seven percent of those surveyed were unsure how HHW could impact land use and water quality. In a similar study, McEvoy and Rossignol (1993) found that although 52% of those surveyed knew of some educational information on HHW but, almost all HHWs were improperly disposed. Motor oil was properly disposed by 43% of the survey participants. Since HHW encompasses a wide variety of products and product classes, it is likely that participants in the surveys have different views on what products were and were not hazardous. Products used frequently by consumers are less likely to be considered hazardous (Shorten et al., 1995). Surveys also conclude that consumers are unfamiliar with the concept of the cumulative effect (Bass et al., 1990). In other words, consumers do not consider the effects of their product once it leaves their home and combines with the wastes from other households.

These studies all identify that consumers are not familiar with the risks of HHW or are not able to name many HHPs. With the lack of concrete toxicity information as well as evidence that current labeling practices do not convey hazard and warning information, it is not surprising that HHW is not viewed as a significant risk.

The exact risks associated with HHW cannot be determined due to the lack of information defining the potential risks posed by HHW. However, the perception of risk

by consumers has been implied by the numerous characterization studies, and implicitly stated in a study by Shorten et al. (1995). Frequent use of automotive products was found to correlate with decreased risk perception. This result mirrors the well documented studies on risk and risk perception. Activities that are voluntary, controllable, familiar and have a perceived benefit are less likely to be considered risky than those that are involuntary, uncontrollable, unfamiliar and not beneficial (Slovic, 1987). A common household product, consciously purchased and used by the consumer to improve their home through cleaning, maintenance or repair is not perceived as a high risk. One criticism of the use of these risk preferences is that people do not always have the proper information to make an informed decision about the product in question versus other available products (Fischhoff, Slovic, Lichtenstein, 1979). While every consumer may not have the appropriate expert knowledge regarding a particular product, consumers make risk decisions based on a qualitative basis and incorporate legitimate considerations with regards to the controllability of the risk and its catastrophic potential, and therefore should not be disregarded (Slovic, 1990).

Considering that the public has a legitimate perspective regarding their view of HHW, it is likely that it is based on what they know about the subject. This means that either consumers are misinformed about HHW and its risks, or they are properly informed and choose not to change their actions regarding disposal. Since the published information of HHW indicates that consumers are not informed about the potential risks, the next logical research step should be to identify ways to correct misconceptions about HHW and educate consumers about the potential risks associated with HHW. One way to increase the effectiveness of educational information about HHW is to use Mental

Models (Bostrom, Fischhoff, Morgan, 1992). Mental Modeling uses influence diagrams to examine knowledge structure. The first step in mental modeling is to develop an expert influence diagram. The influence diagram consists of key concepts related to the subject in question and is arranged according to how each concept influences another. For example, the total amount of wastes disposed in one year influences the value of landfill space for that year. An expert diagram would contain all the possible influences. This diagram is then compared with those of non-experts. When the two diagrams are compared, the gaps and misconceptions in knowledge can be identified (Bostrom et al., 1992).

To properly educate consumers it is necessary to understand how they perceive HHW and what they currently know about HHW and its potential risks. Mental Modeling has been effectively used in developing educational materials for radon (Bostrom, Atman, Fischhoff, Morgan, 1994; Atman, Bostrom, Fischhoff, Morgan, 1994) Educational materials most closely matching the expert influence diagram for radon were most effective in conveying risk information about radon (Bostrom et al., 1994; Atman et al., 1994). It is possible that proper HHW educational materials will produce similar results.

CHAPTER III

METHODOLOGY

Purpose of the Study

The intent of this study is to provide practical, useful information to community decision makers regarding Household Hazardous Waste (HHW) Management. HHW collections are time consuming to organize and disposal costs are expensive. This study analyzes the costs associated with HHW collection programs and also characterizes the toxicity of the products collected from the same collection. Considering the expense of HHW collection programs, and the great effort required by collection planners to organize them, it seems logical to assume that collections are held because they are known to be worth all the effort, time and money invested in them each year. After participating in the organization of a collection event, it quickly became clear that community decision makers are not fully aware of the impacts of HHW.

The concept for this research project evolved from questions raised about HHW management by community decision makers. This study was meant to provide realistic answers to current concerns about HHW management. In light of the practical goals of this research, a field study methodology was chosen. The essence of a field study approach lies in observation of events in their usual surroundings rather than manipulation of events in a controlled setting (Agnew & Pyke, 1982). Field study observations provide the most accurate representation of occurrences within the given setting. The researcher has little or no control over the field study thus, the results are

unpredictable. Results may be less precise than those from a more controlled study environment. However, a gain in precision means a loss in validity (Agnew & Pyke, 1982). Particular to studies that impact public policy, a loss in validity often means sacrificing a degree of practicality (Roos, 1973).

Practicality and validity were top priorities for this research since it was intended to provide information directly to community decision makers. Issues such as HHW are of great concern to decision and policy makers. An elaborate controlled experiment would cost time and money to perform. The field study approach allows research to be performed with fewer time and money constraints yet still provides valuable conclusions for the decision maker as well as the research community. Field studies are sometimes criticized because the observer's bias may affect the final outcome of the study. However, it is this same past knowledge and bias that allows the observer to screen out information that is not essential to the research project (Agnew & Pyke, 1982). Particular to this research, the field study approach was viewed as the most appropriate choice because of the lack of existing full scale studies. This research is a foundation piece for further HHW research. It is necessary to examine the existing process before additional research needs can be accurately assessed.

Description of Data Source

Costs from a recent HHW collection event and pilot project of a permanent HHW collection facility in Tulsa, Oklahoma were obtained from the sponsoring organization, The Metropolitan Environmental Trust (The M.e.t.). The M.e.t. is a cooperative effort of the city and county government in Northeast Oklahoma created in 1987 to develop solid

waste management solutions for participating communities. The M.e.t. provides planning, education, recycling and other solid waste programs for its members. The M.e.t. members are Bixby, Broken Arrow, Glenpool, Jenks, Owasso, Sand Springs, Sapulpa, Tulsa and Tulsa County. The M.e.t. sponsors two HHW collection events annually, and also oversees plastics and aluminum recycling for the city of Tulsa.

Each year, the M.e.t. conducts a formal bidding process to choose a hazardous waste contractor to collect and dispose of wastes at the semi-annual collection events. A contractor is chosen based on several criteria including: the firm's record of past projects, list of personnel, organization, description of waste packing plan, plan for dealing with problem wastes, the firm's position on affirmative action and the firm's overall philosophy. In addition, the disposal bid is weighted highly in the selection process. Because of the bidding process, the M.e.t. has been able to increase the competition between hazardous waste contractors and as a result, command better services and lower prices. The M.e.t. has worked with different hazardous waste contractors and has gained several different perspectives on HHW management and collection.

The M.e.t. has held semi-annual collection events since 1993 with great success. In an effort to explore new and improved methods of collection, experiment with new pricing schemes and identify new ways to lessen the burden of planning a collection event on The M.e.t. staff, The M.e.t. piloted a permanent collection facility.

In addition to the semi-annual collection event held on April 5-6, 1997, the pilot permanent facility was open from March 15 to May 31, 1997 offering a second approach for community members to dispose of their HHW. The facility was open twice a week on Mondays from 12 pm - 6 pm and Saturdays from 9 am - 3 pm. The permanent facility

was only open for a short period of time to allow the M.e.t. to examine the process and determine if it was a viable option for future HHW collection. This study examines the financial costs associated with the collection event and the permanent facility and analyzes the quantity and characteristics of HHW collected by each approach.

Data Collection

A variety of sources were used to collect data for this study. Cost comparison data were obtained from the disposal company, records from The M.e.t., and participant surveys. Toxicity information was obtained from the current literature.

➤ Cost Comparison

Actual bills and disposal summaries from the April 5-6, 1997 HHW collection event and the permanent facility which was open from March 15 through May 31, 1997 were obtained. The data were compared to determine the most cost efficient disposal plan. Data from the collection event consisted of disposal costs, labor costs and amounts of wastes as well as operations expenses and capital purchases made since the collection events began in 1993. Data from the permanent facility consisted of disposal costs and amounts of wastes. The permanent facility costs were contracted on a per car pricing scheme rather than the traditional pricing scheme based on the amount of waste collected. The collection event used the traditional pricing scheme.

The two collection methods, the collection event and the permanent facility, were analyzed based on the projected cost of operations of each for one full year. The collection costs for a full year are based on holding two collection events, which are

typically held in spring and fall. The October 1996 event was contracted to a different hazardous waste collection firm than the April 1997 event. A decision to estimate a yearly disposal cost by doubling the April 1997 data was made to more accurately reflect current disposal prices and the projected cost of the Fall 1997 event. This approach will provide consistency for comparing the collection event to the permanent facility. Since the permanent facility and the April 1997 collection event were contracted with the same firm, the per unit pricing of wastes and the packing schemes would be the same. If the October 1996 collection data were used, it would not only complicate the comparison process but would provide an inaccurate representation of the actual present yearly costs, since the October 1996 contractor is not scheduled to collect wastes at future events. Since the next fall collection event was scheduled to be held after the completion of this study, doubling the April 1997 collection costs provided the most realistic estimate of the yearly disposal costs.

To develop a per year cost for the collection event, the following depreciation calculation was used to determine the per year cost for each capital expenditure item.

AC = Annual Cost
 C = Cost of Item
 Y = Number of Years in
 Expected Life
 I = Interest Rate

$$AC = \frac{C}{Y} + I\left(\frac{1}{2}C\right)$$

(1)

Other collection event related expenses such as rentals and yearly purchases were tabulated on a cost per year basis. These items and the capital expenditures were added together to determine the operations expenses for the collection event.

Determination of HHW Toxicity

The intent of this study was to use the amounts and types of wastes collected at the April 5-6 collection event and permanent facility in conjunction with toxicity data for household chemicals to develop a toxicity rating for each class of chemical collected. Information on the toxicity of HHPs is scarce. Providing toxicity ratings for each class of product collected would provide insight into which products by class are most toxic and the toxicity of materials potentially disposed in municipal landfills and illegal dumps.

Collection wastes are packaged for disposal and treatment according to the Department Of Transportation (DOT) packing requirements found in 49 CFR 171. Determining the average toxicity of each class of wastes collected would be helpful in justifying collection events across the county, as questions about landfill leachate toxicity are becoming more prevalent. Concern over the toxicity of HHPs is not addressed in the current literature making this study a worthwhile contribution to the existing knowledge about HHW. Reports of specific ingredients found in HHPs are common but the exact toxicity of the product itself and the interaction of the known toxic ingredient within the product are often unknown. For example, benzene a known carcinogen is found in several HHPs such as paint strippers and solvents. The actual impact of the benzene in the product is dependant upon the exact quantity of benzene and its interaction with other ingredients in the product.

In addition to the collection data, a profile of common HHPs and their ingredients along with a toxicity rating was required. To develop the toxicity rating, three pieces of information were necessary: a list of common HHPs, the product ingredients most likely responsible for a toxic effect for each product and a toxicity rating based on the product

ingredients. A publication by The Washington Toxics Coalition (WTC) called *Buy Smart, Buy Safe: A Consumer Guide to Less-Toxic Products* (1994), contains a listing of over 350 consumer products rated according to toxicity. The WTC evaluated each product based on the likely hazards encountered from using, storing and disposing of the product. Information from the product label, Materials Safety Data Sheets (MSDS), manufacturer brochures, product ingredients and toxicology references were used to determine the toxicity rating. The WTC rated these products according to their acute toxicity, chronic toxicity, physical and/or chemical hazards and environmental impacts.

A similar, but more comprehensive reference is the *Clinical Toxicology of Consumer Products* (Gosselin, Smith, Hodge, 1984). This publication lists several hundred formulas for common household products. It lists the ingredients according to the percentage typically found in the products, identifies those ingredients likely to be responsible for major toxic effects and provides a toxicity rating based on those ingredients. Products are listed according to category of use, such as "detergents" or "adhesives." Like the WTC data, toxicity determinations are based on available information about the product and its ingredients. Knowledge of the product category, ingredients, and toxicity should allow for a determination of the overall toxicity of each class of products collected during a HHW collection.

In addition to the amount of wastes collected and disposed and the cost data, participant surveys were taken at both the collection event and the permanent facility. The short survey for the event asked participants about what type of waste they brought, if the waste was all residential waste and the number of households the waste represented. In addition, the participants zip code and how they heard about the collection were

tabulated. The permanent facility survey asked the length of time at address, types of wastes brought to the collection, and an estimation of how dangerous HHWs are (based on a scale of 1-10). The survey also asked about the participants occupation, and if their place of employment recycled. The surveys were kept short for participant convenience and to keep traffic moving quickly through the collection event.

Definition of Terms

The following definitions and abbreviations will be used throughout the text.

Hazardous Household Products (HHP) - Identifies products considered as Household Hazardous Waste (see Above) but refers to them in use or, prior to disposal.

Household Hazardous Waste (HHW) - Products purchased by consumers for use within their home that may contain toxic ingredients which are a threat to human health and the environment when improperly used, stored or disposed. Products commonly considered HHW are: paints, solvents, household cleaners, hobby supplies, pesticides and automotive products. For the purposes of this study, the emphasis is placed on disposal of household hazardous waste, rather than storage and use.

Household Hazardous Waste Collection Event - An organized event, lasting one or two days in which community members bring HHW to a designated site for disposal. Collection events usually occur once or twice a year. For the purposes of this text, a Household Hazardous Waste Collection Event will be referred to as a "Collection Event."

Permanent Household Hazardous Waste Collection Facility - A building or other structure prepared to collect HHW on a regular basis. Permanent facilities are usually open for collection weekly or monthly, depending on the specific needs of a community. For the purposes of this text a Permanent Household Hazardous Waste Collection Facility will be referred to as a "Permanent Collection Facility" or a "Permanent Facility."

CHAPTER IV

HOUSEHOLD HAZARDOUS WASTE: COLLECTION COSTS AND TOXICITY

Introduction

Household Hazardous Waste (HHW) collections have become increasingly popular over the past two decades. Several options are available for those communities wishing to collect wastes. Collection events as well as permanent collection facilities are frequently used with success. Depending on the area and the specific needs of the community, different collection options may be best.

Concerns about the costs of HHW collection is always a important issue for collection organizers and makes HHW management especially important. Providing the appropriate service for the community at a reasonable price is a challenge. In the past, collection events have been reported to cost anywhere from \$40 to \$300 per car (Conn, 1989). Reducing costs may enable communities to expand their programs or offer them more frequently to the community. To help local community planners decide what collection techniques may be best suited for their community, this study explains the current collection costs associated with a semi-annual collection event in Tulsa, Oklahoma. These costs are compared to a permanent facility piloted in Tulsa shortly after the collection event.

Project Description

The Metropolitan Environmental Trust (The M.e.t.) provides the City of Tulsa and the surrounding communities with solid waste programs such as aluminum, plastics and newspaper recycling. Through careful planning and contractor selection, The M.e.t. has been able to command lower costs for each of its collection events since their start in 1993. This is a significant achievement since event costs across the county are typically high.

The semi-annual Hazardous Household Pollutant collection event was held on April 5 and 6, 1997. Participants were able to bring wastes to the site from 10 am to 3 pm on each day. Two thousand two hundred twenty participants brought waste to the collection held in an open parking lot at the Tulsa County Fairgrounds. Participants entered the parking lot and were directed by volunteers to one of five clearly marked traffic lanes. Volunteers then surveyed the participants and asked how they knew about the event, their zip code and what waste types they brought to the event. The car was then directed forward to the unloading zone where a city worker removed the wastes onto a cart and sorted them according to type. Paint products, oil and antifreeze, and other household products were sent to separate disposal areas. Participants were asked not to get out of their car to avoid injuries. After unloading was complete, cars were directed toward the exit. Cars did not wait in line more than 20 minutes due to the efficient unloaders and traffic design. Figure 4 shows a map of the collection site.

The pilot permanent facility was open on Mondays from 12 pm to 6 pm and Saturdays from 9 am to 3 pm from March 15 to May 31, 1997. During this time, eighty-seven participants brought waste to the permanent site. The permanent site was located at the local hazardous waste contractor's facility in Tulsa, approximately 17 miles from the Tulsa County Fairgrounds. In order to keep costs low, initially no advertising was performed. Also, permanent facility participants had to schedule an appointment to drop off wastes. This was done in order to better monitor those taking advantage of the service. Persons wishing to dispose of wastes had to first call the M.e.t. and inquire about the service. They were then issued a confirmation number and an appointment time which the participant presented at the permanent facility in order to drop off their wastes. Since the number of persons utilizing the permanent facility were generally small, some advertising was done after the permanent facility was open. The information was published in the M.e.t. newsletter, but the procedure for obtaining a confirmation number remained the same. After the permanent facility was closed, and the contractor's bills were submitted to the M.e.t. for both the collection event and the permanent facility, the bills along with the survey data were collected for use in this study.

Data from the semi-annual collection were collected and organized by waste type and cost per class of waste. This information was added to the capital expenses spent on collection related materials by the M.e.t. since the first event in 1993. Data from the pilot facility were used to project the costs for a full year of operation. Due to the continuing decline in disposal costs since 1993, only the disposal costs from the most recent collection event were used. It is assumed that as collection events grow more popular and more hazardous waste contractors participate in the HHW collection market prices will

continue to decline rather than increase due to competition. The costs of the collection event and the permanent facility were compared based on the total cost for one year of operation.

After collection the data from both the collection event and the permanent facility, the amount of wastes from each were compared. Figure 5 shows the amounts of waste by type collected at both the event and the permanent facility.

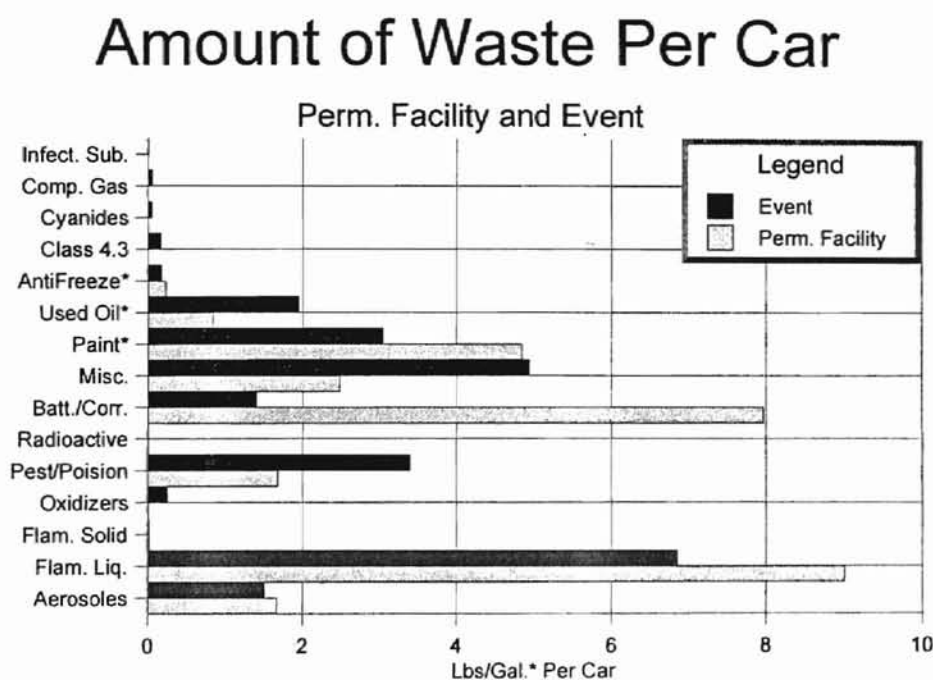


Figure 5: Amount of waste per household collected from April collection event and permanent facility

Permanent facility participants brought more aerosols, flammable liquids, batteries/corrosives, paint and antifreeze than event participants to the collection. It appears that the permanent facility appeals to a different audience than the event.

Collection Data

Event Disposal Costs

Table IV shows the amount of each waste type collected and the cost per class. Explosives were accepted by the local bomb squad, and therefore not taken into account by the collection billing. The contractor did not bill the M.e.t. for used motor oil as part of the collection contract. This was a special agreement made exclusively with the M.e.t. for the April 1997 collection in return for special site accommodations at the collection. This arrangement is certainly not typical of collections across the country. The fee for disposal of all other products was \$67,677 of which the labor fee was \$8,520, and \$550 was charged for the use of a vacuum truck to collect motor oil and antifreeze.

The M.e.t. employed a unique technique for disposing of latex paint at the collection. Latex paint was collected in large roll-off bins and brought to the contractor waste handling site. Paints were then sorted and bulked at the waste handling facility. This made collection faster and cleaner at the event. Typically, contractors will box paint cans in large cubic yard boxes, or bulk paint into large drums for transportation to the waste handling site. Bulking paint at an event is particularly time consuming and creates more opportunities for paint spills to occur. Collecting the paint in roll-off bins allows the paint to be handled quickly without excess packaging. Full cans of paint, found to be in good condition, were sent to a paint swap area where collection participants had the opportunity to select useable cans of paint for their use at no charge. The paint swap encourages recycling, and reduces the total amount of paint disposed. At the April collection event, 1,500 cans of paint were swapped. This results in a considerable

TABLE IV

WASTE AND COST SUMMARY FROM APRIL 1997 COLLECTION EVENT

Waste Class	Amount Collected	Cost per Class	Disposal Method Used**	Cost Per Treatment Type*	Average Cost per class*
Explosives	0	0	-	-	0
Aerosols	3,355 lbs	\$3,321.45	Treatment	\$0.99	\$0.99
Flammable Liquids	15,233 lbs	\$12,637.60	Fuel Blend: Lab Pack	\$0.99	\$0.83
			Bulk	\$0.18	
			Incineration	\$1.20	
Flammable Soils	45 lbs	\$54.00	Incineration	\$1.20	\$1.20
Oxidizers	565 lbs	\$560.40	Treatment	\$0.99	\$0.99
			Incineration	\$1.20	
Pesticides/ Poisons	7,540 lbs	\$9,048.00	Incineration	\$1.20	\$1.20
Radioactive Materials	3.34Cu.Ft. (28 lbs)	\$2,788.90	Store/ Process/ Landfill	\$835.00/Cu.Ft. (\$99.6/Lb.)	\$99.6
Batteries/ Corrosives	3,100 lbs	\$3,096.30	Treatment	\$0.99	\$1.00
			Recycle	\$1.20	
Misc.	10,985 lbs	\$9,792.90	Treatment	\$0.99	\$0.89
			Landfill	\$0.34	
Latex Paint***	135Cu.Yd. (6,750 gal)	\$16,200.00	Fuel Blend	\$120.00/Cu.Yd. (\$2.40/gal)	\$2.40/gal
Used Oil	4,325 gal	N/C	Recycle	\$0.35/gal	N/C
Anti-Freeze	385 gal	\$385.00	Recycle	\$1.00/gal	\$1.00/gal
Class 4.3****	370 lbs	\$444.00	Incineration	\$1.20	\$1.20
Cyanides	110 lbs	\$132.00	Treat/ Incinerate	\$1.20	\$1.20
Compressed Gas Cylinders	130 lbs	\$128.70	Recycle	\$0.99	\$0.99
Infectious substances	15 lbs	\$18.00	Incineration	\$1.20	\$1.20
DISPOSAL COST		\$58,607			

*All rates reported per lb. unless otherwise noted.

**Refers to the way in which wastes are disposed. "Treatment" indicates that a chemical or other process was used to remove the hazardous characteristics of the waste before final disposal.

***Since paint was collected in roll-off bins, the exact amount in gallons was estimated using the following information and formula: 135 Cu.Yd. of paint was collected. It was estimated that 100 cans make up a Cu.Yd. and that cans were all half full. Therefore 135 Cu.Yd x 100 cans x 0.5 = 6,750 gal. Full cans were sent to a paint swap area.

****Substances which in contact with water, emit flammable gasses.

savings for the M.e.t. since paint is one of the most expensive items to dispose of properly.

Event Costs

The actual collection event cost is estimated to be \$182,848 for one year (2 events). This figure is based on the actual fiscal year operations costs for two events (October 1996 and April 1997). This data were used because disposal costs of the fall 1997 collection event were not available in time for this study. While operations costs were based on the actual fiscal year costs, disposal costs were estimated by doubling the April 1997 disposal charge. Table V shows event related expenses incurred since the collection was first held in 1993. The yearly cost of these purchases and rentals is \$47,494. The total disposal cost for two events is projected to be \$135,354. These two figures equal the total collection event cost of \$182,848. The *total collection event cost* per car is calculated as \$41 based on the total cost and a total projected participation of 4,440 cars. This figure includes the cost of disposal, and all other related event costs such as rentals, and purchases made by the M.e.t. for the event. The cost does not include the time spent by the M.e.t. staff on making preparations for the event or the cost of the 35 city workers per day, for a total of 4 days, for the events. It should also be noted that 60 volunteers per day are utilized to help with the event. While this is a worthwhile volunteer activity, and creates a sense of team work and satisfaction for helping the environment, the accessibility of the pilot program and the time saved by the M.e.t. staff to work on other environmental projects should also be considered.

TABLE V

OPERATIONS COSTS ASSOCIATED WITH COLLECTION EVENT

Capital	Cost	Expected Life	Depreciated Cost
Roll-off Bins	\$18,000	10 Years	\$2,520
Oil Collection Apparatus	\$500	10 Years	\$70
Carts	\$5,200	5 Years	\$1,248
Signs	\$542	5 Years	\$130
Household Battery Bins	\$68	5 Years	\$16
Trailers	\$5,608	10 Years	\$785
Subtotal			\$4,769
Rentals/Yearly purchases (Food, T-shirts, Security, Handouts, Tyveck Suits, Porta John Rental, Tent Rental)	\$30,176		
Other Operations Expenses (Consultants, Public Relations, Insurance, Storage Rental)	\$12,549		
Subtotal	\$42,725		
Subtotal from above	\$4,769		
Grand Total	\$47,494		

The depreciation calculations shown in Table V were made as follows:

AC = Annual Cost

C = Cost of Item

Y = Number of Years in Expected Life

I = Interest Rate

$$AC = \frac{C}{Y} + I\left(\frac{1}{2}C\right)$$

Sample:

$$AC = \frac{\$18,000}{10} + 0.08\left(\frac{1}{2}\$18,000\right)$$

$$AC = \$2,520$$

(1)

In Equation 1, the annual cost of the roll-off bins, purchased for \$18,000, is calculated based on a life expectancy of 10 years. The annual cost represents the amount of money lost from the roll-off bins each year considering wear as a result of reasonable use. This depreciation calculation was made for each capital expenditure item listed in Table V. Rentals and yearly purchases and other operations expenses were added to the depreciated costs of the capital expenditure items to determine the total operations costs for the collection event.

Permanent Facility Costs

The pilot facility was contracted with a straight pricing scheme of \$45 per car, rather than by the volume of wastes collected. This was done in order to experiment with a new pricing arrangement in addition to testing a new collection method. The costs incurred by the pilot program are shown in Table VI. Labor was billed on a daily rate that covered a two person team to handle wastes on site while the permanent facility was open.

TABLE VI
TOTAL PERMANENT FACILITY COSTS

	Price	Cost
Disposal of wastes	\$45 per car X 87 cars	\$3,915
Labor	Sat - 125.00/day Mon - \$75.00/day	\$2,125
TOTAL		\$6,040

Conversion of Permanent Facility Disposal Costs

Since the permanent facility was priced on a per car basis, it is not readily comparable to the collection event. To make a comparison, the disposal data from the permanent facility were converted to costs per pound. This was done using the average cost per class, calculated in Table IV from the collection event data. The amount of waste collected multiplied by the average cost per class equals the estimated cost per class for wastes collected at the permanent facility. The results are shown in Table VII.

TABLE VII
ESTIMATION OF PERMANENT FACILITY COSTS
BASED ON PER POUND PRICING

Waste Class	Amount Collected	Average Cost per Class *	Estimated Cost per Class
Explosives	0	0	0
Aerosols	145 lbs.	\$0.99	\$143.55
Flammable Liquids	784 lbs	\$0.83	\$650.72
Flammable Soils	2 lbs	\$1.20	\$2.40
Oxidizers	1 lbs.	\$0.99	\$0.99
Pesticides/Poisons	146 lbs.	\$1.20	\$175.20
Radioactive	1 lbs.	\$99.6	\$99.6
Batteries/Corrosives	693 lbs.	\$0.99	\$686.07
Misc.	216 lbs.	\$0.89	\$192.24
Latex Paint	422 gal.	\$2.40/gal	\$1012.80
Used Oil**	73 gal.	\$1.45/gal	\$105.45
Anti-Freeze	20 gal.	\$1.00/gal	\$20.00
Class 4.3***	0	\$1.20	0
Cyanides	0	\$1.20	0
Compressed Gas Cylinders	0	\$0.99	0
Infectious substances	0	\$1.20	0
TOTAL COST			\$3089.02

*All rates reported per lb. unless otherwise noted. (Calculated in Table IV from collection event data.)

**Used Oil was assumed to be bulked in drums, at a cost of \$80/55 gal. drum. Bulking would have been likely since only a small quantity was collected, unlike the event.

***Substances which in contact with water, emit flammable gasses.

As Table VII shows, if the permanent facility had been billed according to the amount of waste collected, instead of the number of cars participating, the disposal cost would have been approximately \$826 less. A per pound pricing arrangement would have resulted in a savings of twenty percent the per car disposal cost. The \$45 per car price was the proposed cost from the contractor's bid. A detailed analysis of the collection

costs was not performed to determine the per car price. Since the per car *disposal cost* of waste from the collection event is \$26 per car, the contractor's bid was significantly more expensive than the per pound pricing scheme.

It should be noted that the success of per car pricing relies on a relatively even distribution of the quantity and types of wastes brought by participants. This in turn, is dependant on a large number of participants. If an abnormally high amount of paint, or radioactive material had been disposed, the total disposal cost based on pounds, would have been much higher than the \$45 per car rate. It is likely that the contractor calculated the \$45 per car price considering the wide variability of wastes that could be disposed and the small group of participants expected to use the facility. It should also be noted that the \$45 per car price was among the lowest proposed bids. The only bid lower than \$45 per car contained significantly higher labor costs as well as a less desirable site location.

Comparison of Permanent Facility Costs to Event Costs

While it is clear that a per pound pricing scheme is less expensive than the per car price used for the permanent facility, making projections about the cost of running the permanent facility for a full year are difficult to estimate. Two scenarios estimating the one year disposal cost for the permanent facility are presented below. Scenario I represents the lowest estimated cost and Scenario II represents the highest estimated cost. The scenarios calculate differences in disposal cost only. The labor fee was assumed to stay the same as the piloted permanent facility. The collection event budgets for advertising and educational materials was kept the same for the permanent facility

projections to determine the true change in disposal costs. These costs are shown in Table VIII.

TABLE VIII
YEARLY PROJECTED OPERATIONS EXPENSES FOR
PERMANENT FACILITY

	Projected Cost
Advertising	\$6,300
Educational Materials	\$1,600
Labor	\$10,400
TOTAL	\$18,300

The budget for advertising and educational materials should be increased or decreased as needed after determining the type of advertising needed to effectively promote the permanent facility. For the purposes of this study it was assumed that the collection event budget was finite and at its limit, therefore the budget cannot be increased unless the total cost for the permanent facility is less than the total cost for collection events. The yearly labor cost was projected based on the permanent facility being open on Saturdays, 9 am to 3 pm, and Mondays 12 pm to 6 pm for 52 weeks. The daily charge for Saturdays is \$125.00 and \$75.00 for Mondays. Based on a 52 week year, the total labor charge is \$10,400.

Scenario I

This scenario estimates the yearly disposal cost for the permanent facility based on the permanent facility pilot participants. This scenario makes the following assumptions: little or no advertising will be performed, no participants from the collection event will participate, the people using the permanent facility are not similar to those using the collection event, and problems with the pilot permanent facility collection process have been corrected. This scenario provides a good estimate of the lowest possible participation rate for the permanent facility because people who used or intended to use the permanent facility had to learn about it on their own.

It is known that 131 people made appointments to dispose of wastes at the permanent facility. Only 87 actually disposed of wastes. The 44 "no-shows" were mainly people who forgot their appointment and had difficulty locating the site. The 44 "no-shows" are included in the yearly cost estimate because they all demonstrated a willingness to participate in the permanent facility collection. The problems in the collection process are not considered in this analysis, as they will be corrected before the facility can be opened.

Based on the 87 people who brought wastes to the event, the total disposal cost, in pounds, was calculated to be \$3089.02 in Table VII. This averages to \$36 per car. Taking the 44 "no-shows" into account, during the 11 weeks the pilot was open, an average of 12 people per week visited or intended to visit the permanent facility. Assuming this rate to be constant for a full year, 624 people would have visited the pilot during a 52 week period. Using the \$36 estimate, the disposal yearly cost would be \$22,464 for 624 people.

Scenario II

Since the results of Scenario I are likely to be unrealistically low, a second scenario is proposed. Like Scenario I, Scenario II relies on some assumptions: all collection event participants will use the facility, no paint swap will be conducted, motor oil will be collected in drums rather than with a vacuum truck, the permanent facility will be advertised, and the typical event participant is not the same as the permanent facility participant. The last assumption is likely true based on the fact that those disposing of wastes at the permanent facility did not go to the event which was held after the permanent facility opened. Also, the permanent facility participants sought out disposal options rather than waiting for the next collection event.

Since the contractor did not charge The M.e.t. for motor oil at the event, this charge was calculated to determine the cost of disposal of motor oil at the permanent facility. Since the collection event is held at a remote location, a vacuum truck is typically used to collect motor oil. At the permanent facility, motor oil is more likely to be collected in 55 gallon drums because it would accumulate at the facility more slowly than at the event. When collected in 55 gallon drums, the charge per gallon is \$1.45. This figure is discussed in Table VII. Therefore, since 4,325 gallons of oil were collected at the event, it would have cost \$6,271 to dispose of it at the permanent facility.

It is assumed that there will be no provisions at the permanent facility for a paint swap. This means that the 1,500 cans of paint swapped at the event would be disposed by the contractor. It is estimated in Table IV that one gallon of paint costs \$2.40 to dispose. Therefore, it will cost an additional \$3,600 to dispose of the paint otherwise swapped at the event.

The paint and motor oil costs, when added to the total event disposal cost shown in Table IV of \$58,607, equals a permanent facility disposal cost of \$68,478. This disposal cost gives an average disposal cost of \$31 per car, based on 2,220 event participants. In one year, it is assumed at 4,440 participants will visit the permanent facility. Based on the \$31 per car disposal estimate, the total disposal cost equals \$137,640.

In addition to this cost, the participants from the permanent facility must also be added to this total. Since it is assumed that the permanent facility participants represent a non-typical event participant they must also be considered. The estimate of these non typical event participants was calculated in Scenario I to be 624 people with \$22,464 in disposal fees. Therefore the total high estimate for the permanent facility equals \$160,104. Table IX shows a summary of the two scenarios and the fixed operations costs (calculated in Table VIII) for the permanent facility.

TABLE IX
SUMMARY OF PROJECTED COSTS FOR PERMANENT
DISPOSAL FACILITY

Scenario I	Costs	Scenario II	Costs
Disposal (624 participants)	\$22,464	Disposal (5,064 participants)	\$160,104
Operations	\$18,300	Operations	\$18,300
TOTAL	\$40,764	TOTAL	\$178,404

Discussion of Cost

For the purposes of this study it was assumed that the budget for the collection event was finite and at its limit. As shown in Table IX, the highest estimate for a permanent facility is \$178,404. This is less than the cost of two collection events, estimated to cost \$182,848. The Scenario II estimates show that the permanent facility is a more efficient use of funds because the disposal cost represents 90% of the total cost. The collection event disposal cost is estimated as \$117,214 (doubled from April 1997 event) and only represents 64% of the total disposal cost. Items such as advertising were assumed to be at their maximum for the collection event. It is conceivable that advertising costs could be increased for the permanent facility since the overall budget for disposal is reduced by \$4,444. This figure represents the direct savings for The M.e.t. collection event budget. The labor cost for city workers must also be considered in the overall collection event cost. The exact labor cost for the city workers is unknown because this cost is funded through various budgets for the City of Tulsa. However, estimating the cost on a \$10.00/hour wage rate, adds an additional \$11,200 to the total event cost. This figure is based on 35 workers per 8 hour day for two events (4 days). In addition, the volunteer labor represents 720 hours of work that is un- paid. This is based on 60 volunteers per 3 hour day for two events. The M.e.t. staff also spends a total of 832 hours/year on event preparations. The total hours represent two part-time and three full-time staff members. It should be noted that these additional costs only make the permanent facility more feasible because it increases the total collection event cost to well over the \$182,848 figure for costs budgeted by The M.e.t.

Scenario II likely represents the most realistic estimate of the actual yearly costs of the permanent facility. Successful transitions from collection events to permanent facilities have been made in the past, with no reports of decreased participation (Perry, 1996; Farrell, 1995). Scenario II also considers that the permanent facility will likely provide service to a second group of people. This assumption is confirmed by examining the disposal patterns of the collection event participants and the permanent facility participants.

Comparison of Participants

As noted in Figure 5, there is a difference in the amounts of waste disposed by collection event participants and permanent facility participant. This difference could possibly indicate a difference in the type of person using each disposal method. Unfortunately, the difference between the two groups cannot be statistically determined. It is not known what proportion of the collection participants brought a particular class of wastes. In other words, the exact number of collection event participants that brought aerosols to the collection is not known. For the statistical analysis to be sound, it is necessary to know if the two classes of participants differ in the amounts of wastes brought per person as well as the type. Furthermore, there is no standard for which to compare the two groups of participants. To properly determine the true significance of the data, it would be necessary to compare both groups to other collection events and permanent facilities.

Further characterization of the collection event and permanent facility participants was not possible because the event survey data did not include detailed questions, and the

pilot survey data was unusable due to poor surveying procedures by a consultant for The M.e.t. However, it is known that the permanent facility participants brought large quantities of the same item whereas event participants brought several types of HHW to the collection. It appears that the collection event participants are those who "cleaned house" and brought their wastes to the event and the permanent facility participants are those who wanted to find a place to dispose of a particular stock of products.

During the pilot permanent facility program, some participants stated that the permanent site was difficult to locate and others missed their scheduled appointments because of difficulty in locating the site. Eighty seven participants took advantage of the site, while 44 were shown to have missed their appointments. Some participants missed their appointments, because they forgot, while others lost their confirmation number and possibly thought that they could not bring wastes without the confirmation number. It is suggested that The M.e.t. and the contractor work together to make the entrance clearer for those wishing to dispose of wastes as well as possibly providing a map to the site in promotional materials.

It is also suggested that participants be surveyed when they drop off their wastes, in order to keep track of who is using the service and try to identify the type of person taking advantage of the facility. Surveys could include questions pertaining to recycling benefits in Tulsa as well as more detailed questions about how HHW is perceived since there will likely be more time to survey individuals than at the event. Hiring someone to survey participants would increase the cost of running the permanent facility, but it is likely that it will not be cost prohibitive.

Pursuing a pilot facility is a worthwhile option for The M.e.t. In addition to reducing the costs of the overall collection maintenance and operation, it will provide the Tulsa community with a more accessible way to dispose of their HHW. The permanent facility has the capacity to service more people than currently attend the collection event for less cost and increases the percentage of funds spent on disposal, making the permanent facility a more efficient disposal method. Maintaining a place to dispose of wastes year round, may increase the number of people who bring wastes to the facility instead of disposing of them in the trash. People moving, or those who missed the event will benefit from a more accessible collection facility.

Toxicity of Household Hazardous Wastes

A toxicity rating produced by the Washington Toxics Coalition (WTC), was the first attempt at obtaining a list of HHWs with known toxicity. The Washington Toxics Coalition published a rating for over 350 common HHPs. Unfortunately, their ratings included "safe" or "safer alternatives" to HHPs such as vinegar and baking soda. These products are generally not considered HHWs and are not typical of collection events. Also the rating system included several products available only in the Seattle area where the WTC is based. Although the methodology used to obtain these ratings included information from product labels, Materials Safety Data Sheets (MSDS) and product manufactures when available, the final report did not include a list of ingredients making it impossible to match the products with their respective Department Of Transportation (DOT) category.

After an exhaustive search, the most comprehensive profile of product toxicity was found in the *Clinical Toxicology of Consumer Products* (Gosselin, et al., 1984). This publication was originally written for emergency rooms where cases of poisoning with consumer products are generally treated. This information is similar to what would be found at poison control centers. The publication had several shortcomings. First, the last publication was 1984, leaving over 10 years of new HHPs not addressed. Second, no toxicity ratings for pesticides, a significant component of HHW, were given. Third, product ingredients were subject to review by the manufacturer, therefore, some key ingredients may have been deleted from the publication by the manufacturer in order to protect trade secrets.

Despite these shortcomings, over 280 HHPs found in the *Clinical Toxicology of Consumer Products* were cataloged by the ingredient most likely to be responsible for the toxic effects of the product. This list was then compared to the (DOT) List of Hazardous Chemicals. This did not prove to be a successful method of determining the relative toxicity of HHPs in relation to their DOT category since the DOT bases their classification on pure chemicals. Since HHPs are usually a mixture of chemicals they may not retain the same properties as the pure chemicals used in their formulations. The majority of the listed products were considered Flammable Liquids, as most ingredients were organic compounds. While the Flammable Liquids category contained the largest volume of wastes collected (over 15,000 lbs.) the second largest was the Class 9 Misc. category (over 10,900 lbs). The Class 9 category contains other household chemicals not found in any DOT category. Class 9 wastes are determined based on tests performed at the collection. In an effort to determine the contractor's protocol for determining the

classification of wastes, it was learned that individual wastes are frequently tested to determine their hazard characteristics. Since characterization tests are determined "on the spot" they do not provide useable information for this study. In addition, the Pesticide category contained the third largest volume of wastes (over 7,000 lbs). Since no pesticide toxicities were given in the *Clinical Toxicology of Consumer Products*, the results would have been incomplete at best. It was concluded that a determination of the actual toxicity of each category could not be calculated without tracking each product through an actual event.

Discussion of Household Hazardous Waste Toxicity

As a result of searching for toxicity information it quickly became clear that there are several missing pieces to the HHW toxicity puzzle. Besides toxicity, other areas of HHW are not clearly understood. The impact of HHW on municipal solid waste landfills is not fully comprehended. While the literature reports difficulties with injuries to sanitation workers, and water treatment plants, there is no documentation to back up many of these claims (Conn, 1989). In light of these findings a review of the missing pieces of vital information that could have a direct impact on how HHW is managed in the future is included in Chapter V.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Household Hazardous Waste Collection Programs

Household Hazardous Waste collection is becoming an increasingly popular way to handle HHW in the municipal waste stream. As collections are becoming more popular and more hazardous waste handlers are capable of handling these wastes, competition is increasing. Collection organizers should take advantage of this when looking for contractors. In addition, they should use published information and the successes of other collection programs to design a program that best meets the needs of their community.

The collection programs sponsored by The M.e.t. show that careful planning and successful advertising have an impact on the success of a collection event. Accepting bids for the collection events has caused increased competition among contractors. It has also provided The M.e.t. with an opportunity to use various collection techniques and determine the most effective system for their particular situation. It is clear that successful collection events require not only significant funding, but dedication and planning.

As a result of the one year cost projections for the permanent collection facility, The M.e.t. should strongly consider opening a permanent collection facility in Tulsa. This would increase the accessibility of proper HHW disposal for the people of Tulsa. It is possible that the overall cost the a permanent facility could grow larger than the

expense of the collection events due to increased use of the permanent facility. This increase in expense would be more effectively spent on disposal rather than operations expenses. With a permanent facility, the M.e.t. could also expand their collection range with small collections in areas outside the Tulsa city limit. This will help to increase HHW awareness and increase the amount of HHW removed from the municipal solid waste stream. While hosting a small collection will be time consumptive for the M.e.t. staff the presence of the permanent facility allows them the time to plan small collection events and possibly refer event participants to the permanent facility for further collection needs.

The permanent facility is expected to increase the participation of people within the Tulsa area since it is expected that the participants in the pilot permanent facility are not typical event participants. It is also assumed that collection event participants will use the permanent facility and not dispose of their wastes improperly as a result of the change. To further analyze the differences in collection event and permanent facility participants, The M.e.t. should consider a longer pilot of the permanent facility to collect survey data on the participants and the types of wastes they bring. Surveying the participants will provide useful information to both The M.e.t. and the disposal contractor about who will use the facility and the disposal needs that must be met.

To further reduce the cost of the permanent facility, it is suggested that a paint swap be arranged on a semi-annual basis. The paint swap will serve two functions. First, it will reduce the quantity of paint disposed at the permanent facility and thus reduce the overall disposal cost. Second, it will create an advertising opportunity for the permanent facility.

Identification of Further Research Needs

In recent years, Household Hazardous Waste (HHW) collections have been increasingly popular (Waste Watch Center, 1995). Household Hazardous Waste is gaining some popularity through the increase of collection events and permanent facilities across the country. Unfortunately more is known about collection and permanent facility management than the actual toxicity of the products called Household Hazardous Wastes. In an attempt to supply a piece of needed information regarding toxicity of household hazardous products, it quickly became clear, in this study, that the amount of missing information far outweighed the amount of available, known information. The current literature does not provide a comprehensive look into all aspects of household hazardous waste. The two most significant pieces of information lacking are 1). an assessment of the actual toxicity and environmental impact of HHW and 2). the impact of HHW educational materials. There is still much needed research before any definitive statements about HHW toxicity or the overall impact of HHW collection events and permanent facilities can be made. This section explains why continued research is vital to HHW management and discusses the impacts this information will have on HHW education and HHW collections.

Permanent Facility Costs

The M.e.t. should consider refining the cost analysis presented in this study by piloting another permanent facility. The facility should be open for a longer period of time and advertised to allow more people to use the facility. Participants should be

surveyed to determine the type of person using the facility. In addition, collection event participants should be surveyed to determine their HHW disposal preferences. •

Characterization of HHP Toxicity

HHWs are often considered to be harmful both to consumers in the home if used improperly, as well as dangerous to those who encounter HHWs through the disposal process. Although this is a logical conclusion for a potential harmful product, reports of injuries to sanitation workers, damage to municipal water treatment plants are unconfirmed (Conn, 1989). Chemicals found in HHPs are suspected of contributing to landfill leachate toxicity but disposal of industrial wastes complicates this issue making HHWs a likely, but unconfirmed toxicity source (Schrab et al., 1993; Karpinski and Glaub, 1994).

Modeling landfill leachate production could provide substantial insight into the actual contributions of HHW to landfill leachate toxicity but require information on HHPs and their individual toxicity that is not readily available (Gapinski, 1988). Such studies could provide significant pieces of information because they may provide concrete evidence about toxicity in a landfill as well as the cumulative effects of the disposal of multiple products.

HHW Management

It is obvious that characterization of HHW toxicity and further evidence of HHW contamination will enhance the credibility of educational materials and HHW as a solid waste management issue. Increasing risk perception will likely have a positive impact on

HHW management since increased risk perception has been shown to impact the priorities of agencies such as EPA (Slovic, 1990).

According to state results of grant awards for solid waste management, states receiving grant awards typically use some of the funding for equipment, market development and diversion of "non-traditional wastes", which includes HHW (Goldstein and Glenn, 1997). It is possible that considering the fact that landfill size has decreased the least this past year and the market appears to be saturated with recycling and composting programs, that HHW disposal may be the next large area to target in terms of removing wastes from the landfill stream (Goldstein, 1997).

Toxicity information is crucial to determining the impact of collections on the waste stream. With participation rates of 1%, it seems logical to ask whether or not these events are making a significant impact on landfill toxicity. Participation rates are suspect because communities calculate them differently. There is no common method for determining the actual participation rate (Conn, 1989). Comparison studies on landfills in areas with and without successful collection events may help to answer questions about landfill toxicity. In addition this information should be of great interest to areas trying to implement new programs.

Household Hazardous Product toxicity information may also affect the management of HHW by providing money saving information to small communities. In areas where a full collection event is not possible, toxicity data on classes of products may help communities identify the best products to target through a collection when collecting all HHWs is too expensive.

As collection events are costly, every effort should be made to keep costs down and make the event cost-effective. To the author's knowledge, no study has been performed to analyze the benefits of a collection, considering the reduction in toxicity in a landfill and the costs of running a collection. It is obvious that there is still much needed information in regard to collection activities. The success of the collection events in recent years proves that there are at least a small population of interested consumers and city planners that could still benefit from additional information about HHW collections and toxicity.

Policy Implications

Management issues deserve concrete information about HHW. Currently, information is not available and the concentration of information lies in characterizing the lack of knowledge of consumers. Needed research must go beyond this to make any significant contributions to the existing body of knowledge. The current lack of information is stifling the research efforts of others. The toxicity of HHPs must be determined for HHW to gain any further credibility and recognition as a serious solid waste issue. Toxicity information will also help collection organizers and city planners provide better management opportunities.

Conducting research studies about HHW toxicity are extremely important for the future of HHW management. Without knowing the exact impact of collection events on landfill leachate toxicity, it is difficult to justify collection events on more than the idea that they appear to be "politically correct." Assuming that HHW collection events make a positive impact on the environment without concrete evidence, does not provide the

assurance that community decision makers will need to justify continued funding of collection programs versus other important community needs. In the same way concrete HHW toxicity data may increase HHW collection program funding thus, diverting greater quantities of HHW from landfills.

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