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THE IMPLICATIONS OF BEHAVIORAL ASPECTS ON THE PRODUCTION AND DISCARD OF HOUSEHOLD HAZARDOUS WASTES

The University of Arizona M.A. 1985

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THE IMPLICATIONS OF BEHAVIORAL ASPECTS

ON

THE PRODUCTION AND DISCARD OF HOUSEHOLD HAZARDOUS WASTES

by

Douglas Calvin Wilson

A Thesis Submitted to the Faculty of the

DEPARTMENT OF ANTHROPOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF ARTS

In The Graduate College

THE UNIVERSITY OF ARIZONA

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WILLIAM L. RATHJE
Professor of Anthropology

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DEDICATION

For Mary, my wife, and Asa and Patricia, my parents.

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ABSTRACT

Some evidence suggests that the study of the effects of household hazardous wastes on groundwater quality is essential if this vital resource is to be preserved. This study of household hazardous wastes must acknowledge important phases in the flow of hazardous materials from the household to the environment and must recognize different levels of behavior which are responsible for the production and discard of these hazardous wastes in the household. The preliminary support of hypotheses formulated and tested in this thesis suggest that frequency of activity performance and neighborhood sociometric characteristics are two important elements in the production and discard of household hazardous wastes.

CHAPTER 1

INTRODUCTION

It is, perhaps, hard to conceive of the household as powerful enough to affect the natural environment. Our perceptions of the household are based on our own experiences within a family or other small group of people. There are many households though, and in the modern world new, powerful technologies have reached the domestic unit. This technology, among other things, means that products which contain hazardous substances have entered the household. The discarded wastes and residues of these materials, when they are deposited in municipal landfills, are a potential source of groundwater contamination.

The problems of hazardous wastes, including their effects on groundwater which is used for drinking and other needs, has been intensively studied for a number of years. This research, however, has largely neglected the household. Despite this, a number of private and public organizations have recognized the potential dangers of household hazardous wastes and have begun to act. Pilot collection programs and public interventions have provided household members with needed information on household hazardous wastes and encouraged them to reduce the flow of hazardous materials which leave the household as discards.

The cost of these programs and the dangers of handling large quantities of hazardous materials during collections are two problems facing these organizations. In addition, the effectiveness of these programs to reduce the volume of household hazardous wastes entering the waste stream has not been assessed. These problems have not stopped the growing number of communities which have started pilot collection programs and interventions. The response to these programs on the part of the citizen appears to be quite favorable. In American society today there is a heightened concern with hazardous wastes and groundwater protection and an ever-increasing concern about household hazardous wastes. Is this concern about household hazardous wastes justified?

To answer this question it is essential to characterize the types, quantities, and concentrations of hazardous substances in municipal refuse. Without this base-line data it is virtually impossible to adequately evaluate the dangers posed by these wastes. These data, coupled with research on disposal facilities and the natural environment will allow this critical evaluation to be made. This must be done to insure the safety of one of our most important natural resources: groundwater.

It is argued that the data which are available suggest that:

(1) Many common household commodities contain hazardous substances,

(2) These commodities are disposed of as wastes and residues in residential solid wastes,

(3) In some cases residential solid wastes have higher concentrations of hazardous substances than commercial solid wastes,

(4) Residential and commercial solid wastes together can contribute to groundwater contamination through landfills much in the same ways that industrial solid wastes can, and that residential solid wastes, alone, may have this same effect.

Based on this evidence a number of propositions crucial to the study of household hazardous wastes are presented. These outline the relevant research areas which must be studied in order to assess the dangers posed by household hazardous wastes on groundwater. Specifically, three phases of material flow and three levels of generation and discard are proposed.

Proposition I. The study of household hazardous wastes is greatly facilitated by recognizing three phases of material flow in regard to household hazardous wastes and their effects on groundwater: (1) Household Phase--where hazardous wastes are produced and discarded, (2) Disposal Facility Phase--where hazardous wastes are mixed, recombined, and subject to alteration and, (3) Environmental Phase--where hazardous substances may be leached from the landfill, altered and either, attenuated or allowed to enter groundwater.

Proposition II. Three levels of cultural behavior act to affect the production and discard of hazardous wastes in the household phase: (1) Household Level--where activities can produce hazardous wastes and residues and these materials can be discarded in solid wastes, (2) Neighborhood Level--where shared cultural values, beliefs, rules and other sociometric characteristics of the neighborhood affect the nature of activity performance and, therefore, can affect the production and discard of household hazardous wastes, and (3) Community

Level--where legislators and managers must act to regulate and manage household hazardous wastes.

Based on these proposals, a study of the household phase is initiated by examining discard at the household and neighborhood levels. Two hypotheses are made.

Hypothesis 1. The frequency with which an activity is performed affects the type of wear that accrues to a substance, and as a consequence, the quantity and form of household hazardous wastes that result. Specifically, the frequency of discard is inversely proportional to the quantity of wastes that are produced and proportional to the quantity of residues that can be produced. In other words, as the frequency with which an activity is performed increases, greater will be the discard of packaging without appreciable hazardous wastes, but the importance of hazardous residues will be decreased. As the frequency with which an activity is performed decreases, greater will be the discard of packaging with appreciable hazardous wastes, but the importance of hazardous residues will be increased.

Hypothesis 2. The sociometric characteristics of a neighborhood may be used to predict how activity performance occurs in that neighborhood. This means that the characteristics of hazardous wastes produced may also be predicted based on these data.

Both of these hypotheses are tested using household refuse data and are preliminarily supported.

The import of these hypotheses are that both household and neighborhood level behavioral processes act to affect the generation and discard of household hazardous wastes. Any reliable estimates of the

discard of household hazardous wastes, in terms of types, quantities of types, and concentration of types and quantities, must recognize and study these behaviors. The successful implementation of waste management strategies at the community level (and national level) will only be successful if these estimates are made in a systematic, scientific fashion and the dangers to groundwater from these wastes, evaluated.

It is imperative that the study of household hazardous wastes proceed so that the dangers of these wastes may be evaluated, and if necessary, corrective action taken.

Beyond the problem of household hazardous wastes, Hypothesis 2 suggests that household discards reflect differences in households and neighborhoods which (allowing for formation processes) are related to the sociometric constitution of that neighborhood. This has applications outside of modern material culture studies in other areas of anthropology.

The following chapters outline the rationale and basic elements of the study of household hazardous wastes. Chapter 2 discusses hazardous wastes in general, and household hazardous wastes in particular. This includes definitions, generators, and facilities. Groundwater, as the one resource which may be most affected by hazardous wastes, is briefly discussed followed by a presentation of the data which suggest that household hazardous wastes may be dangerous to groundwater quality. Chapter 2 ends with a presentation of the household hazardous wastes flow model (Proposition I). Chapter 3 introduces the household as a unit of analysis in the study of hazardous wastes.

The three levels of Household Phase hazardous waste production and discard are proposed. Two hypotheses which relate to household and neighborhood level behavior are discussed which are tested in Chapter 4. Chapter 4 presents this testing program, including the methods of household refuse collection employed by the Garbage Project and the methods of analysis used to test the two hypotheses. Chapter 5 concludes with the implication of this research, the need for further work and some possible applications of these ideas to other areas of anthropology.

CHAPTER 2

HOUSEHOLD HAZARDOUS WASTES

The intent of this chapter is (1) to briefly explore Hazardous wastes: what they are, who generates them, where they go, and what they affect, (2) to present evidence which suggests that household hazardous wastes may be a significant source of groundwater contamination, (3) to suggest that greatly expanded research in this area is necessary and, (4) to propose three phases of materials flow which are extremely useful for the study of household hazardous wastes and their effects on groundwater.

Hazardous Wastes

The most obvious starting point in a discussion of hazardous wastes is definitions. Hazardous wastes are identified by the presence of hazardous materials in the waste or by fulfilling specific criteria (Metry 1980). The Resource Conservation and Recovery Act of 1976 (RCRA), for example, defines hazardous solid waste(s) based on two criteria:

(1) The waste(s) causes or contributes to health effects (specifically mortality, serious irreversible illness, or incapacitating reversible illness) and,

(2) The waste(s) causes a hazard to human health or the environment.

Many criteria developed by other governmental or scientific organizations include more specific criteria. Criteria usually include both direct hazards of the waste and hazards which must be transferred by vectors. Most criteria include one or more of the following (Metry 1980):

I. Properties of Wastes That May Be Directly Hazardous

Flammability

Corrosiveness

Reactivity

II. Properties of Wastes Which Require A Vector to Become Hazardous

Radioactivity

Bioconcentration
(and bioaccumulation and biomagnification)

Oral Toxicity

Inhalation Toxicity

Dermal Penetration

Dermal Irritation

Aquatic Toxicity

Phyto Toxicity

Genetic Effects
(caused by carcinogens, mutagens, teratogens)

For examples of criteria-based classifications of hazardous wastes see Kohan (1975), Minnesota Household Hazardous Waste Task Force (1985), ABAG (1983), Pioneer Valley Planning Authority (1984).

Lists of hazardous wastes have been compiled by governmental agencies and private organizations and include specific materials within the waste(s) and/or the products from a specific manufacturing process (see Office of the Federal Register:40CFR261 1984, Metry 1980, Weiss 1980, Shuckrow 1981).

Household hazardous wastes have, most often, been defined on the basis of specific materials (or sets of materials) which are constituents in household commodities and may, therefore, be disposed of in household wastes. The term "household hazardous wastes" in this sense does not imply that hazardous substances in household refuse will, in any way, affect environmental resources, but only that hazardous substances are present in the household wastes. The store search is a common method of identifying household commodities which contain hazardous substances and may, then, be discarded as household hazardous wastes. The store search usually consists of three steps: (1) Commonly occurring household commodities are selected for analysis. (2) Store searches are made for these commodities and the commodity constituents (located on their labels) noted. (3) The ingredients of the commodity are compared to lists of hazardous materials (as discussed above) from which lists of commodities which contain or may contain hazardous substances are detailed. Table 1 is an example of one of these lists. The store search method is problematic because many labels may have incomplete or missing data. Missing data are, usually, concentration of the substance in the commodity or in some cases, ingredients. This problem affects the complete accuracy of

TABLE 1

HAZARDOUS INGREDIENTS IN COMMON HOUSEHOLD PRODUCTS

Item	Possible Hazardous Ingredients
Household and Laundry Cleaners and Maintenance	
Toilet Bowl Cleaner	Trichloro-S-triazine trione Sodium Acid Sulfate or Oxalate or Hydrochloric Acid Chlorinated Phenols
Drain Openers	Sodium Hypochlorite Sodium Hydroxide Trichlorobenzene Potassium Hydroxide Hydrochloric Acid Trichloroethenane
Laundry, Dish Related and Cleanser	Surfactants (LAS and others) Ethoxylated Alchohols Methylene Chloride Tetrachloroethylene Sodium Hypochlorite Perchloroethane
Ammonia, Glass Cleaner, Disinfectant	Ammonium Hydroxide Surfactants (LAS and others) Ethoxylated Alchohol Xylenols Sodium Hypochlorite Phenols Ammonia Diethylene Glycol
Furniture and Metal Polish	1,1,1 Trichloroethane Petroleum Distillates Mineral Spirits Petroleum Solvents Oxalic Acid Denatured Ethanol or Isopropanol Phosphoric Acid
Floor Cleaner and Wax	Diethylene Glycol Petroleum Solvents Ammonia

TABLE 1, Continued

Item	Possible Hazardous Ingredients
Oven Cleaner	Sodium or Potassium Hydroxide
Automotive Maintenance	
Lubricating Oils	Petroleum Distillates (Petroleum Hydrocarbons) Lead
Engine/Gas Treatment and Flush	Petroleum Distillates Mineral Spirits 1,1,2 Trichloroethaylene Methylene Chloride Xylenes Toluene Methylene Chloride
Antifreeze/Coolant	Ethylene Glycol Methanol
Auto Wax, Polish	Petroleum Distillates
Degreaser, Rust Preventor/ Remover, Flat Tire Fixer	Toluene Chlorinated Aliphatic Hydrocarbons Potassium Dichromate
Paint and Glue	
Paint	Toluene Xylene Methylene Chloride Halogenated Aromatic Hydrocarbons Mineral Spirits
Paint Thinner	Toluene Chlorinated Aliphatic Hydrocarbons Esters Alchohols Chlorinated Aromatic Hydrocarbons Ketones

TABLE 1, Continued

Item	Possible Hazardous Ingredients
Stain/Varnish	Pentachlorophenols Methylene Chloride Mineral Spirits Petroleum Methyl and Ethyl Alchohol Benzene Lead
Glue	Toluene Methyl Ethyl Ketone Acetone Hexane Methylene Chloride Asbestos Fibre (Asbestos Cement)
Solvent, Sealer, Wood Putty and Stripper, Paint Remover	Methylene Chloride Toluene Trichloroethylene Benzene Asbestos Ketones
Plant/Yard/Pet Maintenance	
Fertilizer	Concentrated Potassium, Ammonia, Nitrogen, Phosphorus
Pesticides	Aromatic Petroleum Hydrocarbons Petroleum Distillates Napthalene Xylene Carbamates Chlorinated Hydrocarbons Organophosophorus Urea Uracil Triazine base Coumarin
Herbicides	Chlorinated Phenoxys Dipyridyl Nitrophenols

TABLE 1, Continued

Item	Possible Hazardous Ingredient
Other	
Batteries (Auto and General Purpose)	Mercuric Oxide Sulfuric Acid
Selected Cosmetics (Nail Polish and Remover)	Aromatic Hydrocarbon Solvents Acetone Ethyl and Butyl Acetate Toluene Alchohols Dibutyl Phthalate

Compiled from: Gerahty and Miller, n.d., Curtis and Anderson 1984, and The Garbage Project.

lists of household hazardous wastes without more intensive research and/or chemical testing of the commodities. Despite this problem, it is obvious from the lists that households use a very wide variety of commodities which may contain hazardous substances.

Hazardous waste generators may be classified as large-scale industrial firms, small-scale commercial enterprises, agricultural enterprises, and households.

Many of the waste products of industrial manufacturing in modern society contain hazardous wastes. The overwhelming amount of publicity that these wastes have received is reflected in the heavy emphasis, by both legislators and scientists, on the many aspects of industrial-generated hazardous wastes.

Commercial enterprises have also received some attention. Many of the waste products of small-scale commercial enterprises are considered hazardous. One example is used photochemicals from film processing. Some commercially derived hazardous wastes are produced by inadequate storage of hazardous materials. For example, underground storage tanks used for petroleum storage may leak allowing hazardous wastes to directly enter the environment.

Modern agricultural technology includes many varieties of pesticides, herbicides, and fertilizers, some of which may produce hazardous wastes, either by direct application on fields or by the disposal of the materials as wastes.

Household hazardous wastes were, until recently, largely ignored by persons studying hazardous wastes. As will be seen later in this

Chapter, some evidence suggests that household hazardous wastes should not be neglected.

Hazardous wastes are disposed of in various forms. The form treated here will be hazardous wastes disposed of as solid wastes. Large quantities of hazardous wastes are disposed of as solid wastes. The U.S. Environmental Protection Agency (EPA) defines solid wastes as any garbage, refuse, any sludge from waste treatment, water treatment, or air pollution control plants, and most other solid discarded materials (Office of the Federal Register 1984). Hazardous wastes in solid wastes are an important source of environmental pollution. The scope of this thesis only addresses hazardous solid wastes. Although other forms of hazardous wastes are also important, they will not be treated here as there is not the space to fully discuss all forms of hazardous wastes.

The hazardous solid wastes problem involves not only what hazardous wastes are and who generates them, but also where they go.

The disposal of solid wastes (including municipal garbage) is a very complex process. Disposal facilities for solid wastes are most commonly landfills, land application units, and surface impoundments. Landfills are locations where solid wastes are deposited on or in land. Land application units deposit wastes on land for beneficial purposes (as fertilizer, for example), including especially sewage sludge and composts. A surface impoundment is a feature designed to hold both liquid wastes and solid wastes containing liquids. All three types of

facility may receive municipal, industrial, commercial, or agricultural solid wastes.

One other disposal alternative, which is of increasing interest to solid waste managers, is waste to energy processing. In some instances waste to energy processing is a viable alternative to land disposal. In waste to energy processing, solid wastes are separated into recyclables, combustibles, and non-combustibles, either manually or by machine, and the combustible fraction--paper, plastics, and other materials--burned to produce energy. Problems with the combustibility of solid wastes and the eventual disposal of ash wastes which may still contain hazardous substances are two important areas of discussion when analyzing the effectiveness of these facilities.

The EPA, in the past ten years has attempted to better regulate solid waste disposal by defining three types of facility: the open dump, the subtitle D facility and the subtitle C facility. Over the years the definitions of these facilities and the wastes they receive has changed.

In 1976 the Congress enacted RCRA, the Resource Conservation and Recovery Act. In compliance with this act, in 1979, the EPA outlined criteria for distinguishing sanitary landfills from open dumps. The criteria included pollution, safety, and environmental hazards caused by the interaction of the facility with floodplains, endangered species, surface water, groundwater, agricultural land, and air. Included were criteria on disease and safety issues caused by solid wastes disposal. The sanitary landfill became the core of what was

termed the subtitle D facility (after subtitle D of RCRA): the approved, safe, and sanitary location to dispose of most solid wastes.

A third facility was created expressly to receive hazardous wastes, primarily from industries. This facility was termed the subtitle C facility (after subtitle C of RCRA). Subtitle C facilities have superior siting and leachate retention, monitoring, and collection characteristics. Despite these new definitions and controls, problems still occurred. When the EPA, as part of Superfund (CERCLA), compiled the National Priorities List to determine which disposal sites (including open dumps, subtitle D, and subtitle C facilities) posed the most significant dangers to environmental purity and public health, almost fourteen percent were subtitle D facilities (Oxer 1985). This indicated that the existing criteria which defined these facilities and regulated the solid wastes which they received were inadequate to protect human health and the environment.

Because of these problems the EPA has recently legislated that a great majority of hazardous wastes from small quantity generators of hazardous wastes--essentially commercial enterprises--must also be disposed of in subtitle C facilities--the facilities expressly designed for hazardous wastes.

These new regulations still exclude all household hazardous wastes and hazardous wastes produced in very small quantities by commercial generators. These wastes are usually disposed of in subtitle D facilities, primarily municipal landfills. The question is,

will the new regulations be enough? Will certain subtitle D facilities which only receive household hazardous wastes and low quantities of small quantity generator hazardous wastes still endanger the environment and human health? As the artifact which receives the brunt of these wastes, the municipal landfill is a crucial element in answering these questions.

The EPA estimates that there are 94,200 subtitle D landfills in the United States, 18,500 of which are municipal landfills (Shuster 1985). These landfills receive the great majority of solid wastes generated in the United States.

A typical sanitary landfill consists of a series of cells of solid wastes. Each cell is a quantity of solid wastes collected over a period of time (ideally, one day's collection). Around the cell are layers of sterile sediments which prevent the spread of infectious disease and allow a buffer between the solid wastes and surrounding environmental resources. In some landfills, liners, leachate collection systems, and leachate monitoring systems are present to better manage the solid wastes. These management techniques are emplaced both to monitor and reduce the effects caused by leachate.

Leachate is produced in the municipal landfill when water, most commonly rainwater, is allowed to percolate through the solid wastes. This leachate may contain hazardous wastes which have been deposited in the landfill or created in the landfill by chemical, physical or biological activity.

Liners, in theory, act as an impervious boundary between the solid wastes and the surrounding environment preventing the escape of leachate. When the landfill is full, a cap (like the cap on a bottle) is placed on top of the landfill to prevent leachate from escaping over the sides of the liner. Liners and caps are most commonly composed of clay or PVC plastic (Matrecon 1980, Fung 1980). Unfortunately, certain chemicals disposed of in solid wastes degrade the effectiveness of certain liners and caps and it has been found that liners and caps will allow leachate to escape into the environment. Leachate collection systems are designed to pump leachate which has escaped from the landfill. This prevents the contamination of ground and surface water. The pumped material is either redeposited in the landfill (allowing the landfill and natural environment to more fully attenuate the material) or transported to a subtitle C facility. Leachate monitoring systems allow the landfill operator to monitor the concentration of undesirable constituents in the water underneath a landfill and allow prompt corrective action to be taken when necessary. Wells are the most common monitoring device.

The reasons for these intricate pieces of technology are because of the serious and expensive problems which have been caused by hazardous wastes. Hazardous wastes are frequently recognized as a detriment to the quality of air, land, and water. The actual methods of identifying hazardous wastes as the source of environmental pollution and human health problems, most commonly, use four types of information (see Committee on Inter-State and Foreign Commerce 1979, U.S.

Environmental Protection Agency 1975): (1) presence of large quantities of hazardous wastes, (2) poor landfill design and disposal methods, (3) groundwater contamination, and (4) unusually high rates of birth defects and illness. The underlying inference is that 1 + 2 causes 3 + 4.

The Love Canal represents a very sensitive and controversial example of the use of these types of information. Health risks caused by hazardous wastes at the Love Canal prompted a massive relocation of households. Federal and State funds totalling to approximately 20 million dollars were expended to move over 500 families. Besides the huge amount of media publicity, this case produced a great deal of controversy within the scientific community and helped to spur further research on the problems of identifying hazardous wastes pollution and health effects caused by hazardous wastes. The actual evidence that initiated this huge expenditure of money and greatly increased interest in hazardous wastes was (1) the presence of large quantities of chemicals--at least 21,000 tons of chemicals including acids, mercaptons, phenols, toluenes, chlorobenzenes, and pesticides (Mann 1984) and (2) inconclusive reports that health problems in Love Canal residents were in higher proportions than the rest of the United States (Levine 1982). The evidence that contaminants had actually left the site of deposition was only confirmed after the residents had been relocated (Mann 1984). The only real evidence that hazardous wastes had caused a problem, then, was the presence of the hazardous wastes.

It is obvious from this example that the estimation of the characteristics of hazardous wastes that leave a generator is a crucial aspect of any hazardous wastes research.

The successful management of solid wastes is extremely important for insuring the safety of one crucial natural resource in particular: groundwater.

The contamination of groundwater is probably the most serious effect that hazardous wastes can produce. It is essential that groundwater as a natural resource be protected from polluting agents. The reasons for this are quite clear. Groundwater is the largest fresh water source in the world next to the glaciers and icecaps. Of the water used by the world, one-fifth is groundwater (Raghunath 1982). Over 64 million people in the United States use groundwater--approximately thirty-seven per cent of the entire population (Murray and Reeves 1975)--and some large metropolitan areas (including Tucson, Arizona) and many rural areas are wholly dependent on groundwater. This dependence of the United States and the world on groundwater indicates that this vital resource must be protected from all forms of contamination, including contamination by hazardous wastes.

Household Hazardous Wastes Groundwater Contamination

The study of the effects of hazardous wastes on groundwater is one of the most important areas of applied research today. As an element of this, the study of household hazardous wastes, and their effects

on groundwater quality is of the utmost importance. Four principal conclusions may be derived from evidence which suggest that household hazardous wastes can be a significant polluter of groundwater:

(1) Many common household commodities contain hazardous substances--this has been outlined above under definitions of household hazardous wastes (see Table 1).

(2) These commodities are disposed of as wastes and residues in residential solid wastes.

(3) In some cases residential solid wastes have higher concentrations of hazardous materials than commercial solid wastes.

(4) Residential and commercial solid wastes together can contribute to groundwater contamination through landfills much in the same ways that industrial solid wastes can, and that residential solid wastes, alone, may also have this effect.

These conclusions were reached from examining the evidence from two areas of research: the monitoring of municipal subtitle D landfills and the characterization of residential solid wastes for the types, quantities, and concentrations of constituent hazardous substances.

Monitoring includes the characterization of groundwater underneath municipal landfills which can evaluate the end product of the transmission of hazardous materials out of the landfill and into the environment. Waste characterization of residential refuse estimates the input of these materials into the landfill. The analysis of these two points: groundwater near landfills and household hazardous wastes

as they are generated will allow the modelling of a third point--the activity of the materials between the household and the environment and allow a comparison to other hazardous wastes generators and the effects they cause.

Two studies, in particular, report the examination and analysis of groundwater underneath municipal landfills in Oklahoma and Minnesota.

A report in 1976 by the EPA and the School of Civil Engineering and Environmental Science found hazardous industrial organic chemicals in the groundwater under the Norman, Oklahoma municipal landfill (Dunlap et al. 1976). Many of these chemicals were of the same types as those produced by industry yet only commercial and household solid wastes had ever been deposited in the landfill. This indicated that household and commercial solid wastes probably contained some of the same hazardous materials as industrial solid wastes and in sufficient quantities to be leached into the groundwater below the landfill.

In 1984 the Minnesota Pollution Control Agency published their analysis of the leachate from 6 municipal landfills--three urban, receiving industrial, commercial, and residential solid wastes and three rural, receiving only commercial and residential solid wastes (Minnesota Household Hazardous Waste Task Force 1985). They found that the leachate from both types of landfills contained similar hazardous materials and that, in many cases, the concentrations did not differ. This suggested, as in the Norman, Oklahoma study, that the materials

originated from widely used commercial and domestic products (such as common cosmetics and automotive maintenance commodities).

These two studies indicate that municipal solid wastes can contribute to the formation of leachate which contains hazardous substances and which is in many aspects indistinguishable from many industrially derived leachates.

Residential solid waste characterizations follow two forms--actual hands-on analysis of the solid wastes, and generator surveys.

In North Santa Clara County, California, in 1982 two units of data were analyzed for solid wastes material constitutents (Glaub et al. n.d.). These were rear loader solid wastes and front loader solid wastes. Rear loader solid wastes were primarily from residential sources, while the front loader solid wastes were primarily from commercial sources. The investigators discovered that residential solid wastes (rear loaders) had higher concentrations than commercial solid wastes (front loaders) of: aluminum, barium, lead, magnesium, phosphorus, potassium, total phosphates, soluble chlorides, BHC, ethyl parathion, and 2,4-D (a chlorinated phenozyacid herbicide). These materials, if concentrated in groundwater, can cause sickness, death, and/or serious long-term health effects.

In 1979 Gurnam and Associates reported that concentrations of heavy metals in household commodities may contribute to wastewater pollution. These same substances are found in solid wastes and may be contributors to groundwater contamination. These materials include

lead, nickel, and zinc (in motor oils, dishwasher detergents, laundry soaps, as well as many other common household commodities).

The County Sanitation Districts of Los Angeles County (1983) performed a study in Southern California that reported that residential wastes entering the Puente Hills landfill were non-harmful. This conclusion was inferred from sampling truckloads of Los Angeles County refuse, counting the number of containers which might bear hazardous wastes, and recording any "wastes" in those containers. This was, then, compared to the total tonnage of solid wastes. When, however, the number of containers which might contain hazardous wastes per ton are compared with similar data recorded by the Garbage Project for Marin County, California, and Tucson, Arizona, a major divergence between cities is indicated. The Marin County containers per ton figure is approximately twenty per cent greater than the figure derived from the Puente Hills report and the Tucson figure is considerably higher than both the figures for Marin County and Puente Hills (Table 2, Figure 1). This suggests that significant variability may exist between cities and the possibility that characteristics of hazardous wastes in one area may be much different in another.

The danger of household hazardous wastes have been recognized by a number of local community-based organizations. Pilot collection programs designed to collect household hazardous wastes have been conducted in many different communities including programs in California, Massachusetts, Florida, and many other states. The quantities of hazardous substances collected from households are astounding--for

TABLE 2

COMPARISON OF THREE CITIES

Puente Hills (Los Angeles County)

249 hazardous waste items

4.14 tons of refuse (not including yard refuse)

60.14 items per ton.

Marin County

160 hazardous waste items

2.12 tons of refuse (not including yard waste)

75.54 items per ton.

Tucson (USDA sample)

1195 hazardous waste items

13.1 tons of refuse (not including yard waste)

91.20 items per ton.

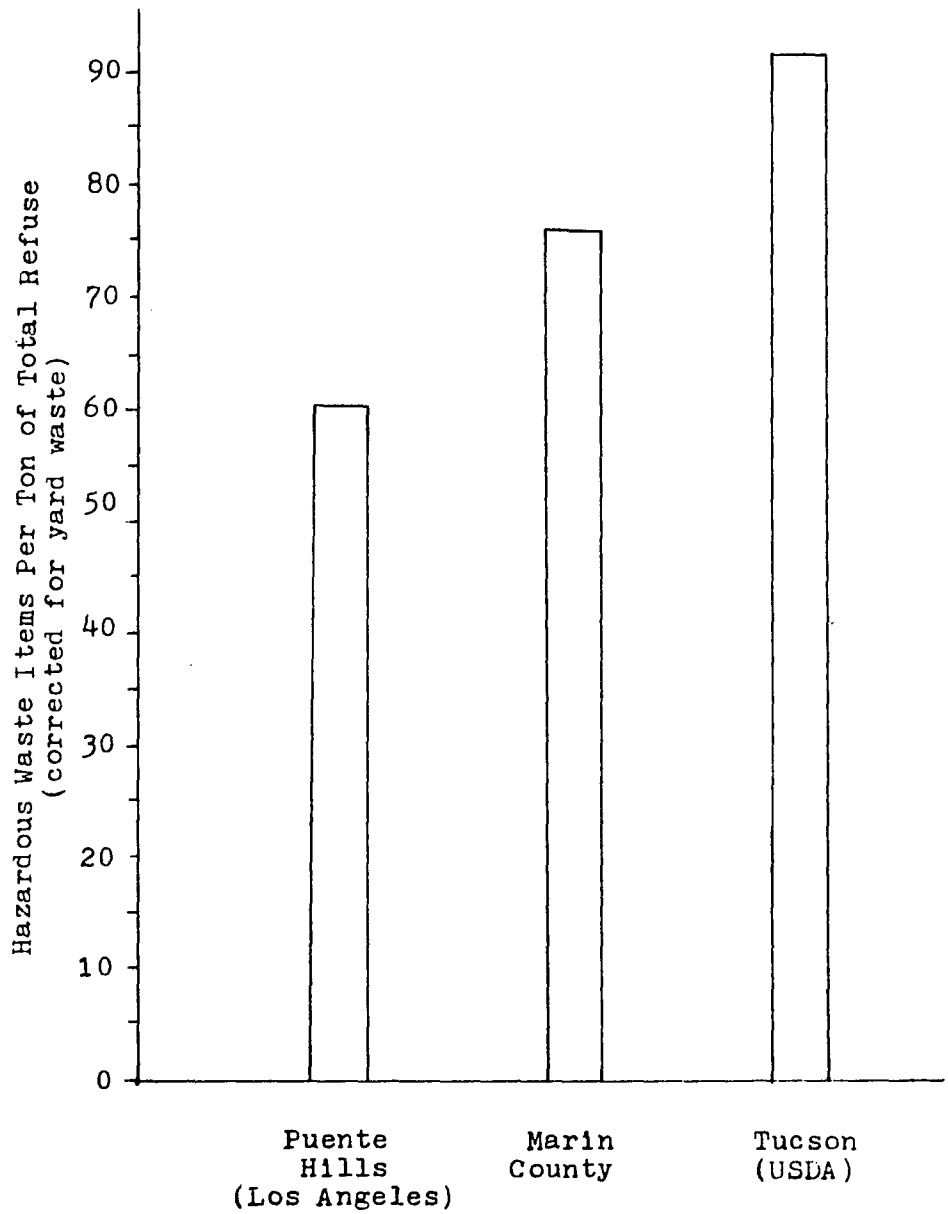

Figure 1: Comparison of Los Angeles, Marin County, and Tucson: Residential Hazardous Wastes

example, one pilot collection program collected three tons of wastes (not including lubricating oils) from 250 households (Golden Empire Health Systems Agency n.d., Purcell 1984). These collections, unfortunately, do not accurately reflect the actual hazardous wastes that are entering the solid waste stream because they rely solely on volunteer action on the part of the citizen and therefore do not constitute a representative sample.

There have been a number of attempts to survey household hazardous wastes generators. The City of Albuquerque Environmental Health and Energy Department estimates that each household disposes of two gallons of household hazardous wastes each year based on their Albuquerque household survey. They believe that most of this is motor oil with lesser amounts of antifreeze, paints, solvents, and thinners (Minnesota Household Hazardous Waste Task Force 1985).

In 1985, the Association of Bay Area Governments published the results of their survey for the Bay Area of California. Their data suggest that the most common household hazardous wastes are household cleaners, pesticides, auto and furniture polishes, paints, and thinners (ABAG 1985).

Problems with the survey method stem from the inability of individuals to accurately specify types and quantities of hazardous wastes, the unwillingness of individuals to implicate themselves as wasters and improper disposers of hazardous wastes, and the problem of low response rates. All of these problems may adversely affect the validity of estimates derived from surveys. For instance, in both

the Albuquerque and Bay Area surveys most of the respondents indicated that they would use a permanent collection station or service if it were available. Data from pilot collection programs, however, suggest that usually less than 1,000 persons in the community actually make use of these facilities and services (Minnesota Household Hazardous Waste Task Force 1985, Pioneer Valley Planning Authority 1984).

Research Directions

These studies argue that residential solid wastes may contain greater concentrations of certain hazardous materials than commercial solid wastes, that they may be more heterogeneous in composition, that concentrations of hazardous materials can leach into groundwater from residential refuse, and that the problems of hazardous substances in household refuse have been recognized and some preliminary documentation has begun. What is lacking is systematic, scientific study which estimates quantities, types, and concentrations of household hazardous wastes and which accounts for variations of geography, seasonality, household socio-economics, and other important factors.

The study of household hazardous wastes is a crucial aspect of the protection of groundwater resources. The most important first step in the study of household hazardous wastes is to determine what aspects of the production, discard, and overall movement of household hazardous wastes must be studied in order to evaluate the dangers posed to groundwater.

It has been mentioned that types, quantities, and concentrations of household hazardous wastes are crucial data. The estimation

of the types and quantities of types are obvious elements in the study of household hazardous wastes. The concentration of hazardous substances in household solid wastes requires a brief explanation. The concentration of hazardous wastes in household solid wastes affects the distribution of hazardous wastes in the landfill. This affects the ease with which substances can leach out of the landfill, in what quantities, and in what concentrations. If hazardous wastes are distributed homogeneously across the distribution of solid wastes in the landfill, the attenuation of hazardous substances is greatly facilitated. If, however, major pockets of hazardous material and hazardous materials of different varieties exist in the landfill, the materials will be more easily leached into the environment and leached in higher concentrations.

The Household Hazardous Wastes Flow

The study of the types, quantities, and concentrations of household hazardous wastes is a crucial element of the study of household hazardous wastes. It is the starting point of the household hazardous wastes flow. Proposition I defines three phases of this flow. These represent relevant research areas of household hazardous wastes research.

Proposition I. The study of household hazardous wastes is greatly facilitated by recognizing three phases of material flow in regard to household hazardous wastes and their effects on groundwater:

(1) Household Phase. In the Household Phase households produce hazardous wastes and residues. These wastes may be mixed with

other solid wastes and are either disposed of on-site or transported to solid waste disposal facilities (including municipal landfills).

(2) Disposal Facility Phase. In the Disposal Facility Phase, hazardous wastes from households are deposited in disposal facilities and are mixed with other solid wastes and broken down and/or recombined. This is dependent on temperature, precipitation, moisture, and the degree of physical, chemical, and biological activity in the disposal facility.

(3) Environmental/Groundwater Phase. In this phase, hazardous substances enter the environment in the form of leachate, migrating gas, and other forms, either from the disposal facility or from direct application of the waste during the Household Phase. The ability of the material(s) to enter the environment and hence the subsurface hydrological cycle is dependent on charactistics of the landfill including liners, the sediment media, the hazardous substances particle characterstics, moisture, temperature, and other hydrological and geological characteristics.

Based on these three phases, the effects of household hazardous wastes on groundwater can be determined by answering three critical questions:

(1) What are the characteristics of the hazardous wastes which leave the household (especially quantity, concentration, and type)?

(2) How is this waste transmitted to groundwater through both (a) the solid waste facility and (b) the surrounding environmental media?

(3) Is this contamination likely to be detrimental to groundwater resources both through health and environmental risks and the drinkability of water?

In terms of the study of the Disposal Facility and Environmental/Groundwater Phases, Cheremisinoff and Gegliello (1983:25) state: "Leachate characteristics vary from site to site and very few general comments can be made with certainty." This suggests that very complex processes work at the Environmental/Groundwater and Disposal Facility Phases that are poorly understood and that to do the basic research required in question 2 will require large-scale, in-depth, site-specific analyses. These analyses, to date, have been a posteriori to the actual indication that hazardous waste from a generator is causing groundwater contamination.

It is obvious that characterization of groundwater underneath landfills must go hand in hand with the characterization of household hazardous wastes. This will allow the modelling of the Disposal Facility and Environmental/Groundwater Phases which will suggest what basic research still must be done to answer question 2. The following chapters discuss Household Phase research and begin to examine some of the behaviors which affect the discard of household hazardous wastes.

CHAPTER 3

HOUSEHOLDS AND HAZARDOUS WASTES DISCARDS

The household is often perceived as wholly incapable of causing serious damage to the environment. The number of individuals that comprise the household are considered too few to seriously affect the immense forces of nature. A single household (or set of households) by itself cannot seriously impact an area. Low technology, low population hunter-gatherer bands are illustrative of the limited effects that a single household has on a region (see for example, Tonkinson 1978:30-31).

It is even hard to conceive of our technologically "rich" households as a source of environmental pollution. It is usually perceived that only industry and other "large-scale" organizations have mobilized sufficient power and materials to be the cause of groundwater contamination and other damage to natural resources.

The example of Love Canal (discussed above) is an excellent example, where the chemical company, in this case Hooker Chemical, was able to amass more than 21,000 tons of chemicals in one location (Mann 1984). In the past forty years, large scale industry, commerce, and agriculture have substantially increased their ability to affect the environment in ways never before approached. Subsequently, in the past

twenty years industry, commerce, and agriculture have been increasingly implicated in issues of air, water, and land quality.

The overall mistrust of industry's motives in these issues accentuates the citizen's willingness to put the majority of the blame for environmental and health effects caused by hazardous wastes on large-scale organization. For instance, in one survey eighty-five per cent of the citizens of a community with significant pollution problems mistrusted the cleanup actions of the chemical corporation that had probably caused the problem (Hamilton 1985).

Improved technology, which is at the root of the hazardous wastes problem, has touched more than just large-scale organizations. Large quantities of new products are available to do a wide variety of tasks. New materials to do old tasks more efficiently and effectively have filled the market and innundated the household. New tasks, creating new markets, have been invented in order to sell new products. As Erik Wolf (1966:6) has suggested: "The instruments and techniques of a particular technology are the product of a prolonged process of cultural accumulation in the past. . .Once a technology has come to include these items, however, they become part and parcel of everyday existence, and hence, culturally necessary."

An example of this flood of new commodities which have become "culturally necessary" in American society is the wide variety of yard maintenance products including pesticides, herbicides, and fertilizers now available. Fifty years ago no one sprayed systemic pesticides on

their flower gardens because systemic pesticides did not exist for the household market.

This improved technology has led to the entrance into the household of more and more products which contain hazardous substances. Now, many commodities for household cleaning, yard, pet, and automobile maintenance, painting, and many other purposes contain hazardous materials as constituents (see Table 1). It is only reasonable, then, to hypothesize that this new technology, along with larger populations, may allow the household to produce sufficient quantities of hazardous wastes to pose serious dangers to groundwater quality and the safety and health of humans in general. The previous chapter has presented evidence which suggests this may be the case. This chapter begins to evaluate the household as a generator and discarder of hazardous wastes. This is the initial step toward answering the question: What quantities, types, and concentrations of hazardous substances are discarded by the household in solid wastes? This discussion presents some definitions of the "household": both basic definitions used by anthropologists and the actual use of definitions in Household Phase research (specifically, the definitions used in this analysis). In order to model household hazardous wastes production and discard in the Household Phase, the pathway model is discussed and some important addendums suggested. The proposition that behavior operates at three levels to affect the form and the relative dangerousness of household hazardous wastes (Proposition II) is presented and two hypotheses

dealing specifically with the Household and Neighborhood Levels of behavior proposed.

Household Definitions

The definition of "household" is a highly problematic undertaking. Anthropologists, early on, defined the household in relation to the family. The "ideal family", based on rules of kinship and marriage, formed the "typical household". Wilk and Netting (1984) suggest that the term "household" was actually a term which defined the actual population of domestic units as compared to the "ideal" familial domestic unit.

Recent definitions of the household have separated the family from the household. The household, most often, is conceived as a domestic unit which performs activities. Hammel (1984) defines the household as the unit larger than an individual controlling resources for its members. Certain constraints on the resources which can be controlled are included in Hammel's definition. The household, according to Carter (1984), is defined by activities related to production and consumption. Wilk and Netting (1984) expand on this to include "spheres" of activity related to production, distribution (including consumption), transmission, reproduction, and co-residence. They define households as "groups in which there is a high density of activity" (5) and note other important activity spheres (for example, defense).

Wilk and Rathje (1982) suggest that the household is composed of social, material, and behavioral elements. This suggests that there

is a morphological component to the household--the demographic unit and material residues--as well as a behavioral and social component.

Household classifications can take on different forms. Wolf (1966), for example, suggests that the household can be classified based on its production alone. This includes its ability to meet the caloric minimum of its members, the replacement cost of its technology, and the requirements of funds of rents and ceremonial funds.

Hypothesis 2 of this thesis suggests that the household can be classified by the solid wastes that it discards. This is because the residues of its consumption in some ways reflect its production, transmission, co-residence, and other important "spheres" of activity.

Of particular importance to household hazardous wastes research are two definitions of the household.

The United States Department of Commerce, Bureau of the Census (1982) writes: "The basic enumeration unit in the census is the housing unit--a house, an apartment, or a single room or group of rooms occupied or intended for occupancy as a separate living quarters." The persons that inhabit the housing unit are the household members as long as it is their "usual place of residence." The census has a long list of specific criteria for determining the location where "household members" actually live. This morphological definition based on co-residence is in some ways different from the Garbage Project's.

The Garbage Project defines the household based on its definition of the garbage pickup: "all of the refuse set out by an individual household on a pickup day for city collection." (Hughes 1984: 42). The household, then, is the unit that creates garbage pickups.

What this means is that numerical transformations (in some cases--such as with apartment complex dumpsters) and assumptions must be made in order to make data from census sources comparable to data from the Garbage Project. This is because the people creating and discarding hazardous wastes will not always be the same people who comprise a "household" at any one point in time. One specific assumption which makes census data comparable to Garbage Project refuse data is:

Assumption 1. Variations due to visitors, guests, and other changes in household structure and or function will not substantially affect the household hazardous waste stream. This suggests that (1) regularities in household form and function (as perceived by the census) in most of the households of a sample will greatly outweigh variations in small numbers of households at the same time. (2) Changes in household form and function that do occur will have limited effects on the household hazardous waste stream. This is because sociometric characteristics of guests, visitors, and other household additions will be largely the same as the original household sociometric characteristics and household tasks related to household hazardous wastes will not seriously change due to the addition of members and changes in household function.

The Pathway Model

The pathway model (Schiffer 1975, Schiffer 1976, Hildebrand 1978) used principally in Archaeology, is an important tool for understanding how hazardous substances are generated and discarded by the

household. The pathway model may be summarized in equation form as:

$$D_t = tDi$$

where: D_t is the total quantity of an artifact type discarded, t is the duration of activity performance and, Di is the number of i type items discarded per unit time.

Di is defined as:

$$Di = \frac{(1-ri)}{bi} Fa$$

where: ri is reuse of i (with 0 = no reuse and 1 = total reuse), bi is the use number--the number of uses of an i type artifact per uselife, Fa is the activity rate, or the number of occurences of an a type activity per unit time.

Substituting for the first equation,

$$D_t = t \frac{(1-ri)}{bi} Fa.$$

For example, if a pesticide has twenty uses (bi), is used twice per week (Fa) for twenty weeks (t) and the container is not reused, then,

$$D_t = 20 \frac{(1-0)}{20} 2$$

$$D_t = 2 \text{ items.}$$

The use number (bi) is an especially important element of the Pathway Model. It is crucial for understanding how materials are actually used in the household. The pathway model, in this regard, does not completely describe the important aspects of wear and how these processes are used to derive the use number. A further definition of

use number includes these aspects of wear:

$$bi = \frac{Ui}{ua}$$

where: Ui is the wear time--the total period of time required to use up an i type item, ua is the use time--the time an i type item is used per an a type activity.

Wear time is calculated from both actual time in use and the physical, chemical, and biological processes that reduce or otherwise decrease the effective life of an artifact. This includes accretional and attritional wear, deterioration due to cultural causes and breakage (see Schiffer in press). For example, continuous stress on an aerosol can valve can cause strain which may break the delivery mechanism of the tool, rendering the materials remaining in the container unuseable. Wear also includes deterioration and breakage due to natural causes. For instance, evaporation causes the constituents of a liquid to become a vapor removing material from the useable portion of the substance. Hildebrand (1978) suggests a natural deterioration factor based on storage life, quantity, and use.

Related to wear time is use wear retardents which prevent certain use processes from acting. For example a cap on a bottle of liquid retards evaporation of the liquid.

Accidental wear which may result in ad hoc maintenance can be contrasted with regular wear both of which may be in the form of accretional and attritional wear, deterioration and breakage (Ad hoc maintenance is maintenance in response to accidental breakage or

spillage) (see Schiffer in press). Wear time, then, can be thought of as the time required for use processes, including regular wear, accidental wear, and natural wear, to render an artifact unuseable, minus the actions of use wear retardents.

Use time refers to the time that the implement is actually used during an activity and includes those use processes that act on the tool. For example, during the activity of painting, a certain brush might apply a quantity of paint at a certain rate for a given period of time. At the end of the activity, the useable portion of the paint has been reduced by a set quantity. A more complex example would be a butchering task in a lithic-technology-based culture. A lithic implement might be used for slicing meat. That slicing might take ten minutes overall at a steady pressure of five kilograms on a surface with soft surface characteristics, and as a result, micro-flakes are removed, polish and striations are formed, and the edge is dulled.

Discard activities also affect how used-up items are discarded. Provisional refuse is refuse which accumulates in a locus prior to removal as secondary refuse (see Schiffer in press)--for example, the contents of a wastepaper basket. The disposal of solid wastes as provisional refuse may also be modelled:

$$DE = \frac{V_t}{C_t}$$

where: DE is the number of disposal events of provisional refuse per unit time, V_t is the volume of refuse produced per unit time, C_t is the total volume capacity of the refuse aggregation area.

Total volume capacity of a refuse aggregation area is affected by both physical properties of the container and cultural behavior. Some cultural factors which affect how much refuse may be accumulated in an area include the hazardousness of the refuse, the periodicity of provisional refuse removal, and revulsion to the presence or decomposition of certain organic (or other) materials over an extended period of time.

Hazardous materials, for example, in provisional refuse may mandate an adjustment in the provisional refuse removal schedule. Certain materials may not be allowed to become provisional refuse, but directly become secondary refuse. The composition of provisional refuse may dictate how full a provisional refuse container will be before it is emptied. This suggests that the provisional refuse container has both a physical capacity and an effective capacity, the effective capacity being equal to or less than the physical capacity.

The number of disposal events required to produce one item from an i type activity (Ai) may be stated as:

$$Ai = \frac{DE}{Di.}$$

For example, if a pesticide has a Di of .10/week and there are three discard events per week for the provisional refuse aggregation area, then,

$$Ai = \frac{3}{.10}$$

$$Ai = 30 \text{ disposal events/1 item.}$$

The pathway model is an important element of the study of household hazardous wastes. The elements of the pathway model should be addressed by an investigator if the characteristics of hazardous substances in residential solid wastes are to be accurately estimated.

As will be shown below, two elements of the pathway model are the most important for describing variations in household hazardous wastes discard. These are how the substance is used (ua) and how often tasks which use that material are performed (Fa). Certain assumptions, then, must be made about the other elements of the pathway model, specifically:

Assumption 2. Ui is constant in all households.

Assumption 3. ri is constant in all households.

Assumption 4. DE is constant in all households.

These elements are constant in a statistical sense, variations averaging out to a normal mean.

Three Levels of Behavior

To examine how ua and Fa vary to produce household hazardous wastes differently, it is important to recognize three levels of behavior which act in different ways to determine the characteristics of household hazardous wastes. This proposition is:

Proposition II. Household Hazardous wastes discard involves three behavioral levels: (1) Household Level, (2) Neighborhood Level, and (3) Community Level.

Household Level. At the household level the behavior of persons in households affects how hazardous wastes are produced and

discarded. Households consume a very wide variety of commodities and can discard as wastes and residues an equally impressive variety of hazardous waste materials. The location in the household where activities are performed and the performance of these activities, in many instances, determines how these wastes are created and is extremely important in considering how these wastes are discarded.

Some common domestic activities which can be important generators of hazardous wastes are housecleaning, household maintenance, clothing care, and automotive maintenance.

Cleaning and maintenance can be defined as both the "beautification" and "protection" of the housing unit. Schiffer (in press) differentiates regular (scheduled) maintenance from ad hoc maintenance (as discussed above).

A fairly frequent household activity is housecleaning. These activities act through the removal of material (such as dirt), addition of material (polish), or rearrangement of material. Common household commodities which contain hazardous constituents and are used during many of the tasks associated with housecleaning include toilet bowl cleaners, drain openers, dish detergents, cleansers, ammonia, disinfectants, and furniture polishes (see Table 1).

Clothing care maintenance is similar to household cleaning. It is performed frequently in the household. Some laundry products which contain hazardous constituents include detergents, bleach, fabric softeners, and stain removers (see Table 1).

A less frequent household activity is household maintenance. Household maintenance is similar to housecleaning with the exception that household maintenance may result in substantially longer-term effects. Household maintenance tasks include painting, caulking, staining, varnishing, gluing, and some pest control. Many common household commodities which are used in the performance of these tasks contain hazardous constituents (see Table 1).

Automotive maintenance tasks allow the automotive vehicle to function properly--both in a technological sense (the running of the machine) and a cultural sense (the message that is conveyed about the owner from the outward appearance and performance of the vehicle). Motor lubricating oils and carburetor cleaners are two examples of commodities which contain hazardous substances related to automotive maintenance (see Table 1).

Neighborhood Level. Because households are different, composed of different types of members from different backgrounds, it is possible that neighborhoods with distinctive cultures, access to resources, and other elements reflected in sociometric parameters, will discard household hazardous wastes differently from other neighborhoods. This is because individual households perform activities similarly in the neighborhood based on their shared knowledge, beliefs, goals, access to resources, and other aspects of society. This may be predictable by using specific sociometric characteristics which determine how important activities are performed and consequently, how

hazardous wastes are discarded. Three such characteristics are income, ethnicity, and family size.

Income reflects the basic access to resources that a household has (converted into a monetary quantity). Although this does not treat all of a household's assets, it does provide a good method for evaluating basic access to resources.

Family size indicates the number of humans which may be used as resources, must be maintained, or otherwise counted by the household.

Ethnicity is a good reflection of the cultural background of a group of individuals. Ethnicity may indicate that values, technology, and other facets of a cultural store of knowledge may be shared by most of the members of that group.

Community Level. There are two aspects of the community level. One aspect is the physical location of the community which, to some extent, constrains and otherwise affects what hazardous wastes are produced. The behavioral component is the community's input into how solid wastes are regulated, treated, and disposed of.

The environment may, to some extent, determine what tasks are appropriate and how those tasks are performed. The range of certain pests, for example, will determine whether a certain household pesticide will be effective. The nature of water, temperature, and soil quality will determine the type of plant fertilizer that should be used.

The community as a legislative body determines how solid wastes will be collected and how they will be deposited. At a larger level,

State and Federal legislation helps to shape landfill construction and solid wastes management.

At these three levels, behavior operates which largely determines the quantities, types, and concentrations of household hazardous wastes generated in the community and the relative effects they will have on groundwater.

The levels at which household disposal of solid wastes, including hazardous substances in solid wastes, are affected by behavior is diagrammed in Figure 2. At the lowest level are the discards of materials from specific activities such as food preparation and consumption, tobacco consumption, and personal sanitation (Figure 2:I). At the next level is the provisional refuse of a household, indicated by its waste receptacles: paper and plastic bags and milk containers (Figure 2:II). Provisional refuse is aggregated in the household garbage pickup (Figure 2:III) which is collected by sanitation workers along with other garbage pickups in garbage trucks (Figure 2:IV). Depending on how the refuse is collected (community level behavior) these may represent the solid wastes from one neighborhood or many neighborhoods, and may be quite distinctive, or quite homogeneous. Truckloads are deposited at the municipal landfill and mixed with other truckloads collected from similar or very different neighborhoods (Figure 2:V). At this level communities regulate and manage the solid wastes that have been created in the other two levels.

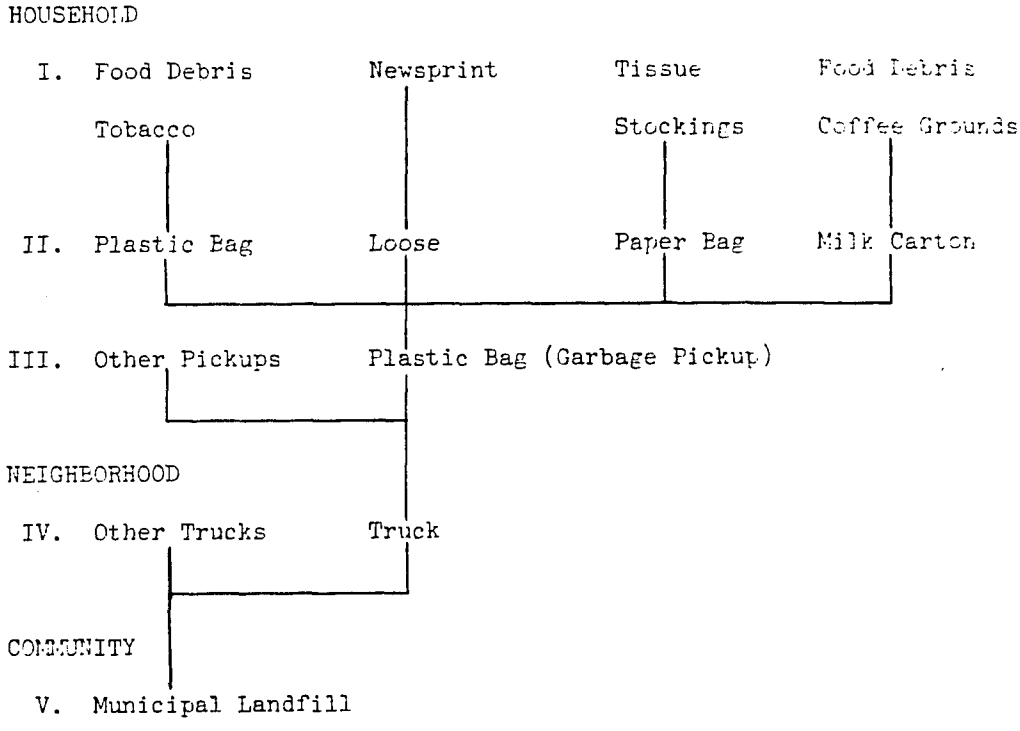

Figure 2: Three Levels of Solid Wastes Discard

Household and Neighborhood Level Behavior

It has been suggested above that the production and discard of household hazardous wastes is affected by behavior acting at three levels: the household, the neighborhood, and the community. Specific hypotheses may be formulated and tested to better understand these behaviors and the consequences that these behaviors have on the contamination of groundwater. Two hypotheses which attempt to describe some of the processes in the production and discard of hazardous wastes at the household and neighborhood levels are:

Hypothesis 1. The frequency of activity performance affects how wear accrues to a substance and consequently how wastes and residues are generated and disposed of. The important distinction between hazardous wastes and residues in household solid wastes is crucial for understanding this hypothesis. Household commodities are generally packaged in relatively small containers--as compared to commercial and industrial packaging. Because of the great number of these packages discarded each year even small amounts of residue on an individual package may result in a considerable quantity of hazardous waste. For this reason both actual wastes and residues must be treated.

In relation to wastes and residues Hypothesis 1 states that the frequency of discard (Fa) is inversely proportional to the quantity of wastes that are produced and proportional to the residues that can be produced. If W represents wastes and R represents the residues that can be produced, then Hypothesis 1 in equation form is:

$$Fa \approx \frac{1}{W} \qquad \text{and} \qquad FA \approx R.$$

In other words,

(1) As the frequency with which an activity is performed increases, greater will be the discard of packaging without appreciable wastes but the importance of residues will increase. This is because cultural wear on the artifact is allowed to take precedence over natural wear and other human behavior which would "use-up" the usefulness of the artifact before actual use (such as obsolescence).

(2) As the frequency with which an activity is performed decreases, greater will be the discard of packaging with appreciable wastes. This is because cultural wear on the artifact is superceded by natural wear and other behavioral processes (as above).

Hypothesis 2. Important sociometric characteristics of a neighborhood may be used to predict the types, quantities, and concentrations of household hazardous wastes. This is because individual households perform activities similarly in the neighborhood based on their shared knowledge, beliefs, goals, access to resources, and other aspects of society. Very important social aspects include income, ethnicity, and family size. Changes in these characteristics will be reflected by changes in the disposal of certain household hazardous wastes. These changes are regular and predictable.

These hypotheses suggest that the household and neighborhood levels are extremely important areas of study for people acting at the community level who are attempting to manage solid wastes and protect critical groundwater resources. The following chapter describes the testing of these hypotheses.

CHAPTER 4

The Testing Procedure

The two hypotheses detailed in the last chapter were tested using household refuse data collected by the Garbage Project between the Spring of 1975 and the Spring of 1985. This chapter outlines the testing program by outlining: (1) Garbage Project history and data collection methods, (2) limitations of Garbage Project data including some formation processes of the "garbage record", (3) the nature of household commodity packaging in relation to how hazardous wastes and residues are produced in the household, and, (4) the procedures used to test (a) the household level hypothesis (Hypothesis 1), and (b) the neighborhood level hypothesis (Hypothesis 2).

Garbage Project History

Since 1973 the Garbage Project has recorded data from more than 12,000 pickups of household refuse. Samples have been collected in: Tucson, Arizona, Milwaukee, Wisconsin, Marin County, California, and Mexico City, Mexico. Additional special samples have been collected in Tucson and New York City (Table 3). Data from the project have been used to answer questions concerning nutrition, interview-survey bias, resource conservation and recycling, consumer behavior, market research, solid waste management, and hazardous wastes (see Rathje 1978, Rathje and Thompson 1981, McGuire et al. 1982, Harrison et al. 1983, Rathje and Ritenbaugh 1984, Rathje et al. 1985).

TABLE 3

GARBAGE PROJECT SAMPLES

Location	Dates	Samples
Regular Sorts		
Tucson, Arizona	1973-present	more than 4,589
Milwaukee, Wisconsin	1978-1979	598
Marin County, California	1980-1981	144
Mexico City, Mexico	1981-1983	more than 2,000
Special Sorts		
Tucson, Arizona	1974-1975	550
Tucson, Arizona	1976	313
Tucson, Arizona	1978-1979	4,361
Tucson, Arizona	1981-1982	1,354
New York City	1984	*
Tucson, Arizona	1984-1985	**

*Analyzed truckloads.

**Still being tabulated.

Within each city/county studied, residential refuse is sampled from neighborhoods with differing socioeconomic characteristics. The basic unit of data is the garbage pickup--the total refuse set out by an individual household on a pickup day for municipal or commercial collection (Hughes 1984:42).

The Garbage Project has used three different data recording formats (see McGuire 1980).

The Regular Sort procedure records every individual material item within a single garbage pickup identified by sample neighborhood and date of collection. Total weight of the refuse is noted and then each item is recorded by item code (87 food codes and 66 non-food codes, Figure 3, 4), number of items, fluid or solid capacity of container (if marked), cost of items (if marked), food "waste", brand of product, type (such as "pesticide"), and the material composition of the container or non-food item (16 catagories) (see Figure 5). The "special indicator" space is used to identify the presence of notes on items requiring further description.

The Weight Sort procedure records the material composition of the garbage pickup by weight. Data on sample area (city and neighborhood) and date of collection are noted, and the solid waste is segregated into seventeen material composition categories which are recorded by weight (see Figure 6).

A Pull is designed to record special interest items from garbage pickups. Three kinds of Pulls have been used by the Garbage Project: (1) Paper Pulls record newspapers and other paper types in

BEEF *..... 001
OTHER MEAT (not bacon)*.... 002
CHICKEN..... 003
OTHER POULTRY..... 004
FISH (fresh, frozen, canned, dried)*..... 005
CRUSTACEANS & MOLLUSCKS (shrimp, clams, etc.)... 006
T.V.P. TYPE FOODS *..... 007
UNKNOWN MEAT..... 008
CHEESE (including cottage cheese)..... 010
MILK *..... 011
ICE CREAM (also ice milk, sherbet)*..... 012
OTHER DAIRY (not butter)... 013
EGGS (regular, powdered, liquid)*..... 014
BEANS (not green beans)*... 015
NUTS..... 016
PEANUT BUTTER..... 017
FATS: Saturated *..... 018
Unsaturated *..... 019
Bacon, saltpork *.... 020
Meat trimming..... 021
CORN (also corn meal and mash)*..... 022
FLOUR (also pancake mix)*.. 023
RICE *..... 024
OTHER GRAIN (barley, wheat germ, etc.)..... 025
NOODLES (pasta)..... 026
WHITE BREAD..... 027
DARK BREAD..... 028
TORTILLAS *..... 029
DRY CEREALS:
Regular..... 030
High Sugar (first ingredient only)..... 031
COOKED CEREALS (instant or regular)..... 032
CRACKERS..... 033
CHIPS (also pretzels)..... 034
UNKNOWN PRODUCE *..... 040
FRESH VEGETABLES *..... 041
CANNED VEGETABLES (dehydrated also)*..... 042
FROZEN VEGETABLES *..... 043
POTATO PEEL *..... 044
FRESH FRUIT *..... 045
CANNED FRUIT (dehydrated also)*..... 046
FROZEN FRUIT *..... 047
FRUIT PEEL *..... 048
RELISH, PICKLES, OLIVES *.. 049
SYRUP, HONEY, JELLIES, MOLASSES..... 051
PASTRIES (cookies, cakes and mix, pies, etc.) *.. 052
SUGAR *..... 053
ARTIFICIAL SWEETENERS..... 054
CANDY *..... 055
SALT *..... 056
SPICES & FLAVORINGS (catsup, mustard, pepper, etc.)*..... 057
BAKING ADDITIVES (yeast, baking powder, etc.)*... 058
POPSICLES..... 060
PUDDING..... 061
GELATIN..... 062
INSTANT BREAKFAST..... 063

DIPS (for chips)..... 064
NON-DAIRY CREAMERS & WHIPS..... 065

HEALTH FOODS *..... 066
SLOP *..... 069

REGULAR COFFEE (instant or ground)*..... 070
DECAF COFFEE..... 071
EXOTIC COFFEE *..... 072
TEA *..... 073
CHOCOLATE DRINK MIX OR TOPPING..... 074
FRUIT OR VEG. JUICE (canned or bottled)..... 075
FRUIT JUICE CONCENTRATE.... 076
FRUIT DRINK, pdr. or lqud. (Tang, Koolaid, Hi-C)*.. 077
DIET SODA..... 078
REGULAR SODA..... 079
COCKTAIL MIX (carbonated).. 080
COCKTAIL MIX (non-carb. liquid)..... 081
COCKTAIL MIX (powdered).... 082

PREMIXED COCKTAILS (alcoholic)..... 083
SPIRITS (booze)..... 084
WINE (still & sparkling)... 085
BEER *..... 086

BABY FOOD & JUICE *..... 087
BABY CEREAL (pablum)..... 088
BABY FORMULA (liquid)*..... 089
BABY FORMULA (powdered)*... 090
PET FOOD (dry)..... 091
PET FOOD (canned or moist)..... 092
TV DINNERS (also pot pies). 094
TAKE OUT MEALS..... 095
SOUPS *..... 096
GRAVY & SPECIALTY SAUCES *. 097
PREPARED MEALS (canned or packaged)*..... 098

VITAMIN PILLS & SUPPLEMENTS (commercial)*..... 100
PRESCRIBED DRUGS (prescribed vitamins)... 101
ASPIRIN *..... 102
COMMERCIAL STIMULANTS & DEPRESSANTS *..... 103
COMMERCIAL REMEDIES *..... 104
ILLICIT DRUGS *..... 105
COMMERCIAL DRUG PARAPHERNALIA..... 106
ILLICIT DRUG PARAPHERNALIA. 107
CONTRACEPTIVES:
MALE..... 108
FEMALE..... 109

BABY SUPPLIES (diapers, etc.)*..... 111
INJURY ORIENTED (iodine, bandaids, etc.)..... 112
PERSONAL SANITATION *..... 113
COSMETICS *..... 114

CIGARETTES (pack)*..... 124
CIGARETTES (carton)*..... 125
CIGARS..... 126
PIPE, CHEWING TOBACCO, LOOSE TOBACCO..... 127
ROLLING PAPERS (also smoking items)..... 128

HOUSEHOLD & LAUNDRY CLEANERS *..... 131
HOUSEHOLD CLEANING TOOLS (not detergents)..... 132
HOUSEHOLD MAINT. ITEMS (paint, wood, etc.).... 133
COOKING & SERVING AIDS.... 134
TISSUE CONTAINER..... 135
TOILET PAPER CONTAINER.... 136
NAPKIN CONTAINER..... 137
PAPER TOWEL CONTAINER..... 138
PLATIC WRAP CONTAINER..... 139
BAGS (paper or plastic)*.. 140
BAG CONTAINER..... 141
ALUMINUM FOIL SHEETS..... 142
ALUMINUM FOIL PACKAGE..... 143
WAX PAPER PACKAGE..... 144

MECHANICAL APPLIANCE (tools)..... 147
ELECTRICAL APPLIANCE & ITEMS..... 148
AUTO SUPPLIES..... 149
FURNITURE..... 150
CLOTHING: CHILD *..... 151
ADULT *..... 152
CLOTHING CARE ITEMS (shoe polish, thread).. 153
DRY CLEANING (laundry also)..... 154
PET MAINTENANCE (litter).. 155
PET TOYS..... 156
GATE RECEIPTS (tickets)... 157
HOBBY RELATED ITEMS..... 158
PHOTO SUPPLIES..... 159
HOLIDAY VALUE (non-food)*. 160
DECORATIONS (non holiday). 161
PLANT & YARD MAINT..... 162
STATIONERY SUPPLIES..... 163
JEWELRY..... 164

CHILD SCHOOL RELATED PAPERS *..... 171
CHILD EDUC. BOOKS (non-fiction)..... 172
CHILD EDUC. GAMES (toys).. 173
CHILD AMUSEMENT READING... 174
CHILD AMUSEMENT TOYS (games)..... 175
ADULT BOOKS (non-fiction). 176
ADULT BOOKS (fiction)..... 177
ADULT AMUSEMENT GAMES..... 178

LOCAL NEWSPAPERS *..... 181
NEWSPAPERS (other city, national)*..... 182
ORGANIZATIONAL NEWSPAPERS OR MAGAZINES (also religion)*..... 183
GENERAL INTEREST MAGAZINES *..... 184
SPECIAL INTEREST MAGAZINE OR NEWSPAPER *..... 185
ENTERTAINMENT GUIDE (TV Guide, etc.)..... 186

MISCELLANEOUS ITEMS (specify on back of sheet)*..... 190

*Special Notes Used in Recording Procedures, see Appendix.

Figure 3: Garbage Project Regular Sort Codes

CODE#	NOTE
001	Type for beef will be cut of meat (ie, 'STEAK','HAMBURG'er etc.). If only bones found- 'BONES'. Any meat or organ from a cow will go in this category such as 'VEAL','CALFLIVE'r, 'TRIPE', etc.
002	Bacon, fatback, & saltpork are fats (020) not meats.
005	Type will be 'FRESH', 'FROZEN', 'CANNED' or 'DRIED'.
007	T.V.P. (textured vegetable protein) type foods are generally meat extenders made of mostly soy meal. Also 'MORNINGS'tar products & ground beef mixed with TVP.
011	Type of milk is recorded according to fat content ('WHOLE', 'TWOPERCE'nt, 'LOWFAT', 'SKIM','EVAPORA'ted, 'BUTTERMI'lk, 'CONDENSE'd, or 'POWDERED'). Acidophilous milk should be recorded as 'ACID' and then fat content such as 'ACIDSKIM' or 'ACIDLOWF'.
012	Type will be 'ICECREAM', 'ICEMILK', 'SHERBET', not the flavor.
014	Record shells separately from cartons (put 'SHELL' as type or 'CARTON' as type).
015	Types of beans are: 'KIDNEY', 'PINTO', 'REFRIED', 'LIMA', 'SOY', 'BLACKEYE'd peas, 'CRYPEAS', etc., not green beans or wax beans; they are vegetables.
018	Types of saturated fats are: 'BUTTER', 'LARD', 'SHORTENI'ng (solid) and 'HARDMARG'arine. (If the first ingredient listed is "hydrogenated", "partially hydrogenated" or "hardened", then it is hard margarine. The fact that it is in a tub or in stick form makes no difference.)
019	Types of unsaturated fats are: 'SALADRE'ssing, 'MAYONNAI'se, 'SHORTENI'ng' (liquid), 'COOKINGO'il or 'SOFTMARG'arine. (If the first ingredient listed is soft or liquid anything, then it is soft margarine. Tub or stick form makes no difference.)
020	This includes only pork BACON, not beef bacon, which goes under beef.
022	Types of corn are: 'COB', 'CANNED', 'POPPED', 'MEAL', 'MASA', 'FROZEN', etc.
023	Types are 'BLEACHED', 'WHOLEWHE'at, 'PANCAKEM'ix, etc. (not cake mixes).
024	Types of rice are: 'WHITE', 'BROWN', 'WILD', 'INSTANT', 'MIXED', etc.
029	Types of tortillas are: 'CORN', or 'FLOUR', 'TACOSHELL', 'WHEAT'.
040	If only a container that could contain either fruit or vegetables is found, it should be recorded in this category.
041-3	Vegetables are: Artichoke, Asparagus, Green Beans (string), Wax Beans (yellow), Bean Sprouts, Beets, Broccoli, Brussels Sprouts, Cabbage, Celery, Chili Peppers, Chinese Cabbage, Carrots, Cauliflower, Collard Greens, Cucumbers, Dandelion Greens, Endive, Escarole, Jicama, Kale (greens), Lettuce (all types), Mushrooms, Mustard Greens, Dark Onions, Parsley, Parsnips, Peas (except dried peas count as Beans[DIS]), Peppers (Bell), Pimientos, Potatoes (not chips), Pumpkin, Radishes, Sauerkraut, Spinach, Squash, Summer Squash (zucchini or yellow), Winter Squash (orange or yellow- the kind one bakes), Sweet Potatoes, Yams, Tomatoes, Turnips, Turnip Greens, Rutabaga.
044	Potato peels are weighed and recorded in the waste column. Do not count individual peels, weigh them as a group.
045-7	Fruits are: Apples, Apricots, Applesauce, Avocados, Bananas, Blackberries, Blueberries, Cantaloupe, Cherries, Cranberries, Dates, Figs, Fruit Cocktail, Mixed Fruit, Grapefruit, Grapes, Lemons, Limes, Pomegranate, Melon (other than cantelouce or watermelon), Oranges, Papayas, Peaches, Pears, Persimmons, Pineapple, Prunes, Plums, Raisins, Raspberries, Rhubarb, Strawberries, Tangerines, Watermelon.
048	FRUIT PEELS are weighed separately by type (all orange peel together,etc.), recorded in the waste column, and the type of fruit is put under type. Do not count individual peels, weigh them as a group.
049	Most pickled items go in this category.
052	Pastries are grain products and pies with a high sugar content (cakes, frosting, doughnuts, cookies, etc.) Cake mixes should also be in this category.
053	Types of sugar are: 'WHITE', 'BROWN', 'RAW', 'POWDERED', etc.
055	Types of candy are: 'CHOCOLAT'e, 'GUM', 'HARD', 'CHEWY', 'MARSHMAL'low.
056	Types of salt should be recorded as either 'PLAIN' or 'IODIZED'
057	Dry spices as well as 'MUSTARD', 'CATSUP', 'STEAK', and 'TABASCO' type flavorings go in this category.

Figure 4: Special Notes to the Garbage Item Code List

066 This category contains items that are peculiar to health food stores.

069 SLOP is the once edible conglomeration of plate scrapings and scraps. Non-nutritive garbage should not be included in slops. Weigh as waste and record as one item.

070 Coffee grounds are recorded in this category as 'GROUNDS' and not weighed.

072 These are coffees with chicory or the line of international coffees.

073 Types are 'LOOSE', 'BAG', 'INSTANT', 'CANNED', etc.

077 This category includes both liquid fruit flavored drink and drink mix powder (ie, Hi-C orange flavored drink, Hawaiian Punch, etc.) Real fruit juice goes in category 075.

086 Cans (or bottles) and cartons should be recorded separately with the fluid ounces recorded from the cans only. When the carton is recorded, type should be 'SIXPACK'.

087 Types are: 'MEAT', 'VEGETABLE', 'DINNER', 'DESSERT', 'FRUIT', and 'JUICE'.

089-90 If the formula contains 'IRON', put it under type.

096 If soup is dry, put dry under type (ie, 'DRYONION', 'DRYPEA', etc.)

097 Specialty sauces are things like spaghetti sauce, hollandaise sauce, etc. Salsa, tomato sauce and tomato paste should be recorded under vegetables (042).

098 This category is for foods that are a conglomeration of items such as canned ravioli, spaghettt & meatballs, stews, hash, etc. Also packaged meals such as Lipton dinners, Kraft macaroni and cheese dinners, and frozen pizzas. TV dinners and pot pies have their own category (094).

100 These are over the counter items like One-A-Day, Geritol, etc. Please note any waste by recording the original number of pills and the number wasted on the back of the sheet.

102 Also in this category is acetaminophen such as Tylenol and Daetril.

103 Stimulants and depressants that work on the brain, such as sleeping pills and No-Doz type items.

104 Physical remedies are items such as cough syrup, laxative, nasal spray, Ben Gay rub, etc.

105 Marijuana is placed in this category.

111 Exact count on diapers is not needed. An approximation is sufficient.

113 Personal sanitation items deal with hygiene (ie, soap, shampoo, deodorant, toothpaste, sanitary napkins, razor blades, Clearasil, etc.).

114 Cosmetics are items meant to beautify the individual (ie, perfume, make-up, hair color, hair spray, after shave, bobby pins, etc.).

124-5 Type will be 'FILTER', 'NONFILTE'r, 'MENTHOL', '100MM', '100MMMEN'thol, '120MM', etc. Be sure to put packs under code 124, and cartons under code 125. Record separately.

131 Types of household cleaners are:'LAUNDRYD'etergent, 'LAUNDRYS'oap, 'LAUNDRYL'iquid, 'DISHSOAP', 'CLEANSER', 'BLEACH', 'PRESOAK', 'ALLPURPO'se cleaners, 'WINDOWCL'eaner, 'WAX', etc.

140 The large outer bag is not to be recorded. Record plastic bags separately from paper ones.

151-2 Type will be 'PANTS', 'SHIRT', 'SOCKS', etc.

160 The HOLIDAY will go under brand, and the type of item under type.

171 Type will be 'HIGHSCHO'ol, 'ELEMENT'ary, etc.

181 Brand will be 'STAR', 'CITIZEN', 'WILDCAT'.

182 Brand will be the name of the paper. Type will be the city of origin.

183 This category includes unions, churches, social groups and clubs; also Book-of-the-Month-Club. The specific religion will go under type where applicable.

184 These magazines deal with news, science, sex, fashion, home, etc.

185 These items deal with specific activities or interests (ie, golf, cars, music, etc.)

190 MISCELLANEOUS ITEMS should be recorded in full on the recording sheet with any extra information on the back of the sheet. CHECK WITH THE SUPERVISOR BEFORE USING THIS CODE #

Figure 4 (continued)

M

252 — TOTAL HH WEIGHT (LBS.)

CENSUS TRACT 16 17 18: 8 0 7

COLLECTION MO 19 20: 1 0 — DAY 21 22: 3 1

Freidel/Hughes — NAME OF RECORDER

11/16/79 — DATE OF ANALYSIS

MATERIAL COMPOSITION CODES

CODE (LIST MOST PREVALENT MATERIAL FIRST)

A PAPER
B FERROUS (STEEL/TIN)
C ALUMINUM
D PLASTIC (CELLOPHANE)
E NON-RETURN GLASS
H RETURNABLE GLASS
J AEROSOL CANS
K WOOD
M CERAMICS
P LEATHER
R RUBBER
R COPPER AND BRASS
S BIODEGRADABLE PLASTIC
T TEXTILES
V CORRUGATED CARDBOARD
X OTHER (SPECIFY ON BACK)

PAGE: B07 — 1/5 (TRACT — TOTAL PGS.)

	ITEM CODE 23 24 25	NO OF ITEMS 26 27 28	FLUID OUNCES 29 30 31 32 33	SOLID OUNCES 34 35 36 37 38	COST 41 42 43 44	WASTE (GRAMS) 45 46 47 48	SPECIAL IND 49	BRAND 50 51 52 53 54 55 56 57	TYPE 58 59 60 61 62 63 64 65	MATERIAL COMPOSITION CODE 66 67 68
1	086	6	72.0					STROH'S	BOHEMIAN	CA
2	011	1	128.0					WILKES	WHOLE	AD
3	075	1	64.0		1.65			TROPICANA	ORANGE	ED
4	079	1	67.6					COCACOLA	COLA	DC
5	140	14							PAPER	A
6	140	4							PLASTIC	D
7	022	3		7.5	2.0			MARTHA WHITE	MUFFINS	A
8	079	1	16.0					MOUNTAIN	ITRUS	H
9	079	1	16.0					SPOT	ORANGE	E
10	027	1		24.0	70			WONDER	ENRICHED	DD
11	005	1		3.8				SPIRITOF	SARDINES	CD
12	027	1		24.0				SAEGER	ENRICHED	DP
13	021	2		16.0	2.88			FATRICK	BACON	DA
14	08C	1	12.0					PABST		CB
15	131	1		7.0	83			GLADE		BD
16	057	2		14.0	49			HEINZ	CATSUP	EB
17	003	1		56.0	35			KOHL'S	FRYING	D
18	017	1		12.0	88			JIFF	CREAMY	EB
19	042	1		8.0	17		G		TOMATO	BA
20	030	1		20.0	25			KELLOGG'S	FROSTED	FA

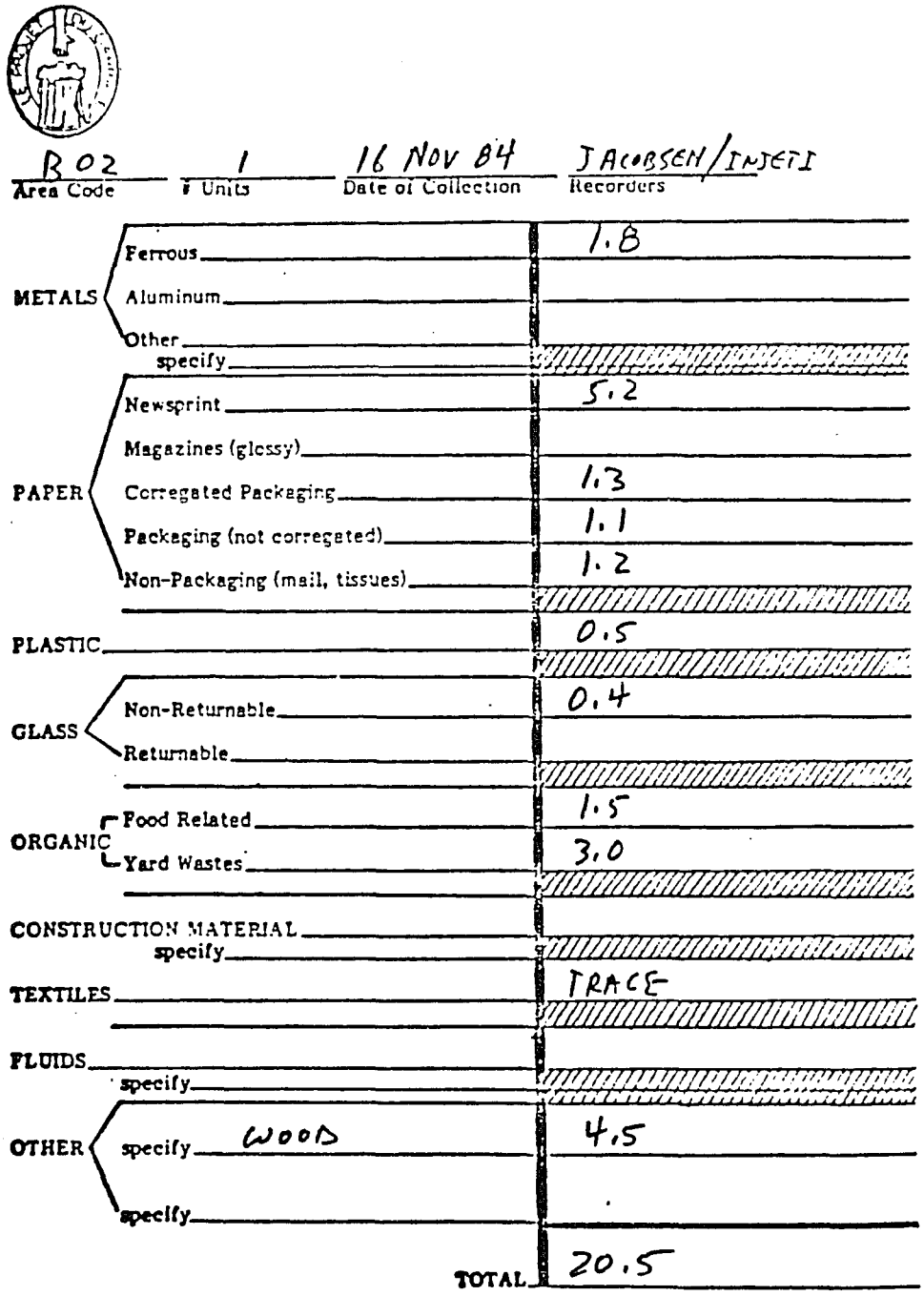

Figure 6: Weight Sort Recording Form

the same format as the regular sort. In addition, each paper type is weighed to compare to the total unit weight. (2) Beverage Pulls record the quantity of beverage containers per unit, generally conforming to the Paper Pull. (3) Hazardous Wastes Pulls record those items containing or once containing hazardous substances with a special code (Figure 7), number of items, capacity of container, material composition of the container, brand of commodity, specific type of item, and the quantity of commodity discarded unused or "wasted" by the household (Figure 8). Presence or absence of hazardous residues (see below) are noted.

Data Limitations

Two problems which limit Garbage Project data used in the sociometric analysis are sample size and sampling distribution. The protection of the citizen's anonymity is a primary concern of the Garbage Project. Because of this concern the sociometric analysis (which tests Hypothesis 2) must use household refuse statistics aggregated at the census tract level rather than the individual household. This limits the sample size of the analysis to the number of census tracts sampled. For the data used to test Hypothesis 2 (collected from the years 1975-1981) thirteen census tracts were sampled in sufficient quantity to be included in the analysis and, therefore, the sample size is also thirteen.

The second problem is with sampling distribution: the data sets for automotive maintenance commodities (which are the commodities

Household and Laundry Cleaners and Maintenance
- 01 Toilet Bowl Cleaner
- 02 Drain Opener
- 03 Laundry Soap (including fabric softener)
- 04 Bleach (and bleach substitute)
- 05 Dish Detergent
- 06 Cleanser (kitchen, household)
- 07 Ammonia, Glass Cleaner, Disinfectant
- 08 Polish (furniture and metal)
- 09 Floor Finish (wax)
- 10 Air Freshener
- 11 Other Household

Auto Supplies
- 20 Motor Oil (and all purpose)
- 21 Transmission Fluid
- 22 Engine Treatment
- 23 Antifreeze/Coolant
- 24 Auto Wax
- 25 Other Auto

Paint and Glue
- 30 Paint
- 31 Paint Thinner
- 32 Stain/Varnish
- 33 Glue
- 34 Painting Tool
- 35 Other Paint, Glue Related

Plant, Yard, Pet Maintenance
- 40 Fertilizer
- 41 Pesticides
- 42 Herbicides
- 43 Pet Collars, Powders, Dips
- 50 Batteries (and electrical)
- 60 Drugs (prescription)
- 62 Selected Cosmetics (nail polish, perfume, and others)

Other
- 70 Hobby Related (dyes, photochemicals)
- 80 Other (including pool chemicals)

Figure 7: Hazardous Waste Pull Codes

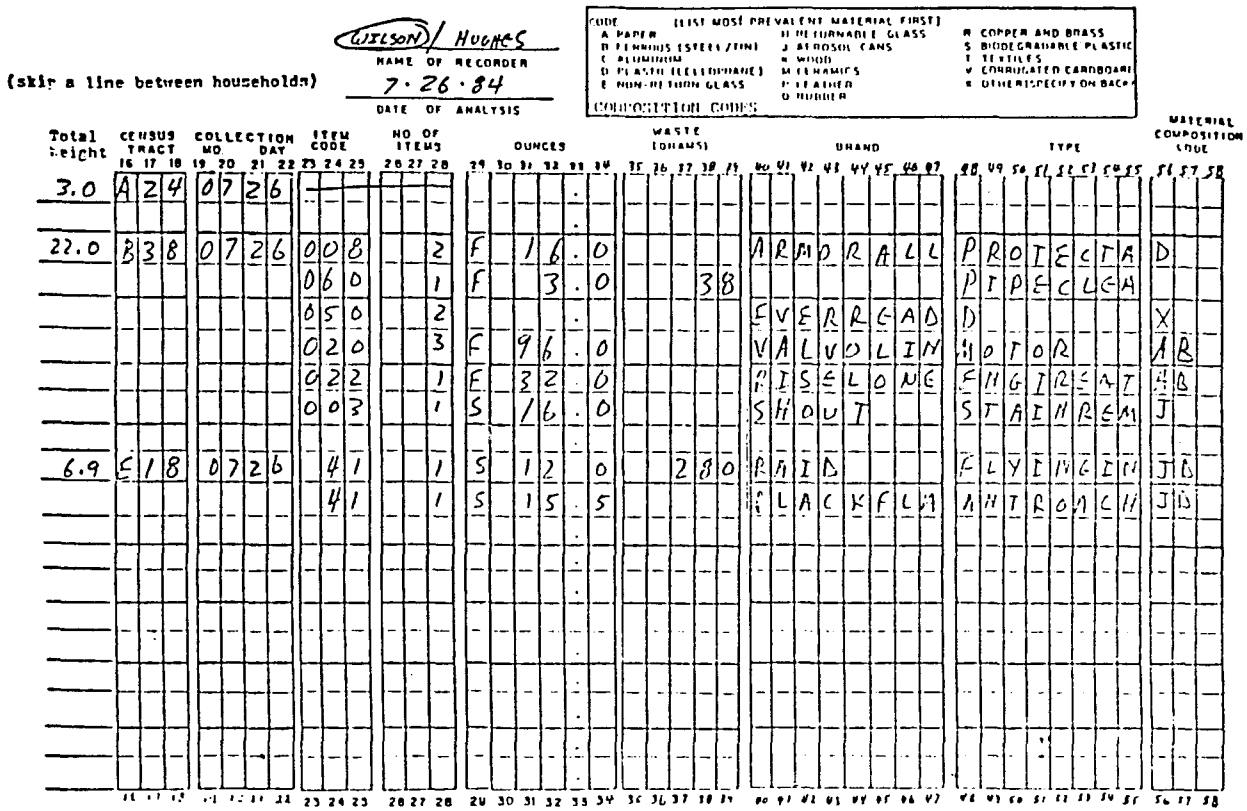

Figure 8: Hazardous Waste Pull Recording Form

used to test Hypothesis 2) display a poisson distribution. This indicates that the presence of these commodities in the garbage pickup is relatively rare.

These two problems limit the amount of variance which can be accounted for in the sociometric analysis regardless of the actual strength of the relationship (for a similar case, see McGuire et al. 1982).

Limitations on the quantity of samples which may be collected and analyzed by the Garbage Project dictate that extreme outlier behavior cannot be adequately assessed. In one case, it was deemed that outlier behavior was operating and this case was removed from further consideration in the sociometric analysis. The case involved sixteen automotive maintenance containers discarded in a single garbage pickup. This probably represents the discards of a part-time automotive maintenance business or some other form of very intensive automotive maintenance activity.

Some Formation Processes of the "Garbage Record"

Compared to many "archaeological records" the materials that the Garbage Project selects for analysis have relatively little chance to be affected by natural or cultural formation processes. Some transformations, however, may be important in the collection and analysis of Garbage Project data especially when it is related to cultural behavior. Although these have not been controlled for, it is important to recognize and discuss their presence and the possible limitations they impose on the analyses.

A very important cultural formation process is recovery techniques. If sanitation personnel select garbage pickups non-randomly or only recover a portion of the total garbage pickup, then recovery techniques have (1) skewed the total sample of garbage pickups and (2) removed potentially critical data from the individual garbage pickup.

Reuse of items may alter the constitution of a garbage pickup. If prescription pill bottles, for example, are reused and then discarded in a location other than the garbage pickup then the container data on prescription pill bottles will be underrepresented (for a discussion of the reuse of items in modern material culture, see Schiffer, et al. 1981). Many of the household containers and the commodities which contain hazardous substances are not as suitable for reuse as the above example may suggest. Reuse may, however, be a source of some error.

Scavenging of materials from refuse can remove data from the garbage pickup. Relatively high value materials, such as aluminum and other metals, are probably the first to be scavenged. Still useful materials (in a relative sense)--magazines, books, electrical parts--may be scavenged.

Natural formation processes which are important transformers of the garbage pickup are the effects of gravity and containment, faunalturbation by pets, and biological, physical and chemical processes acting within the pickup.

Materials may be lost from the garbage pickup by the force of gravity through incomplete containment of the pickup's contents. Faunalturbation by pets, especially dogs and cats, can remove food debris and food debris-soaked materials (such as meat wrappers) from the pickup. Biological, chemical, and physical actions within the garbage pickup can change the materials within, including the addition, deletion, or alteration of materials. One example is the biodegredation of organic materials--such as food remains--which produce methane gas as one by-product.

All of these processes and problems affect how much variability an analysis concerned with sociometric characteristics and household discards can partition. Despite this, it is felt that the data is suitable for testing the hypotheses formulated. This is because (1) the garbage pickup represents the materials which actually end up at the municipal landfill and can potentially contribute to groundwater contamination, (2) the level of analysis for the testing of Hypothesis 2 (the census tract) is comparable to how the solid wastes are picked up and deposited in the landfill by a garbage truck, and (3) patterning which does occur in the analysis will show that the relationship is sufficiently strong enough, despite the transformations of the data and problems with how the data is collected, to suggest that a very strong relationship exists.

A further problem in the analysis of Garbage Project data is caused by the relationship of packaging to the discard of hazardous wastes and residues. Commodity packages may be separated into three

types for this discussion: exterior packaging, negative residue packaging, and positive residue packaging.

Exterior Packaging is packaging not in direct contact with the commodity--the plastic wrap which covers a box, for example.

Negative Residue Packaging is packaging which is in direct contact with the commodity, but either due to the nature of the commodity or the nature of the packaging, the substance does not adhere to the packaging. This results in minimal residue quantities. There is, however, the possibility of wastes in these packages.

Positive Residue Packaging is packaging in direct contact with the commodity and has the potential for significant quantities of wastes and residues.

When studying household hazardous wastes it is very important to identify these kinds of packages--in this case, from the standpoint of Garbage Project regular sort data (which does not include information on wastes and residues) and the Hazardous Wastes Pull data being collected now by the Garbage Project. Exterior packages must not be included in any estimates of residues and wastes, and negative residue packaging must be excluded from any residue estimates. To the fullest extent possible all exterior packaging was removed from consideration in both of the analyses.

Procedures to Test the Hypotheses

The testing of Hypothesis 1--that frequency of activity performance (Fa) is inversely proportional to the wastes produced (W)

and proportional to the residues which can be produced (R) was undertaken using Garbage Project Hazardous Wastes Pull data collected between the summer of 1984 and the spring of 1985.

The procedure to test this hypothesis was to select two sets of household activities which produce hazardous wastes--one set which occurs frequently and one set which occurs much less frequently. The two sets of activities were general household and laundry cleaning and general household maintenance. Hazardous wastes bearing commodities which are associated with general household and laundry cleaning are toilet bowl cleaners, drain openers, laundry soaps, bleach, dish detergents, cleansers, ammonia, polishes, floor finishes, air fresheners, and other basic household cleaning substances (Hazardous Wastes Pull Codes 1-11, see Figure 7). General household maintenance activities are associated with paints, paint thinners, stains, varnishes, glues, painting tools (residue laden), and other paint, glue related substances (including caulking, putty, and others) (Hazardous Wastes Pull Codes 30-35, see Figure 7).

The inference that general household and laundry cleaning activities are events which occur in high frequency and that general household maintenance events occur in low frequency is supported by the discard frequency of each commodity set. Despite problems of comparing relative commodity use times (ua), the sheer magnitude of difference in the quantities of containers from the Pull data indicates that the inference is justified (General household and laundry cleaners occur almost ten times more frequently than general household maintenance

commodities, see Table 3). Even if commodity use time is very different from general household and laundry cleaning in general household maintenance, this does not completely explain the difference in discards. For example, if the two types of commodities from the two sets of activities came in similar sized containers with similar quantities of commodity (which they basically do) and were used at the same frequency, then the use time of general household maintenance commodities would have to be one tenth of the use time of general household and laundry cleaners. This is obviously not the case. Most general household maintenance commodities probably have larger use times than general household and laundry cleaners due to the more extensive nature of the tasks (such as painting).

A problem with relative use times is recognized here that cannot be controlled for due to the, as yet, limited sample size of the Household Hazardous Wastes Pull. Until specific commodities with known use times, different frequencies of activity occurrence, and recorded wastes and residues are compared, Hypothesis 1 will have to remain to some extent untested. Despite this, the testing of Hypothesis 1, here presented, allows the hypothesis to be preliminarily supported or rejected and provides the basis for more detailed analysis later.

Data from the two selected categories were compared for quantity of containers and actual wastes occurring in these containers. For the hypothesis to be preliminarily supported (1) the containers associated with unfrequently occurring activities should have relatively more instances of wastes than the containers associated with frequently

TABLE 4

WEAR AND WASTE ANALYSIS

	Activity	
	Household and Laundry Cleaning	Household Maintenance
Number of Containers	321	34
Number with Wastes	16	7
Percent with Wastes	4.98	20.59
Average Wastes (g)	46.2 n 16	414.9 n 7
Total Waste (g)	739.3	2,904.3

occurring activities, (2) the average quantities of wastes per container should be higher in the containers associated with unfrequently occurring activities, and (3) the total amount of wastes should be higher in the materials associated with unfrequently occurring activities. As is shown in Table 3, the hypothesis is preliminarily supported. Approximately twenty per cent of the low frequency activity-related containers had evidence of wastes while only five per cent of the high frequency activity-related containers had evidence of wastes. The relative quantities of wastes indicate that nearly ten times more wastes are found in general household maintenance commodities. Total wastes produced in general household and laundry cleaning was only a quarter of the wastes produced in general household maintenance commodities.

When residues are considered, if residue quantities form similarly on similar packages to produce similar amounts of residues (which would be the case in a single commodity type), then the difference in residues produced by change in frequency of activity performance is obvious. The more packages discarded will result in more residues. In the analysis, for example, if each package resulted in one gram of residue, the amount of total residue discarded would be:

Total Residue = 1 gram (# packages-packages with waste)

or, 305 grams for general household and laundry cleaners and 27 grams for general household maintenance commodities. More than ten times the hazardous residue produced in general household maintenance activities would be produced in activities related to general household and laundry cleaners. Total hazardous wastes and residues

produced, then, would be 351.2 grams for general household and laundry cleaners and 441.9 grams for general household maintenance commodities. Unfortunately, the formation of residue on different containers has not yet been studied to the extent that residue factors can actually be applied to commodity types. Despite this, it is fairly obvious that change in the frequency of activity occurrence will affect the discard of hazardous residues within specific commodity types.

To test the hypothesis that neighborhood level cultural groups discard hazardous wastes differently and in predictable ways (Hypothesis 2) is tested using Garbage Project data collected between 1975 and the spring of 1981. A specific commodity type was selected for analysis. The commodity type chosen was automotive maintenance. This was for two reasons:

(1) Automotive maintenance is a requirement of the majority of American households and,

(2) Many of the hazardous substances in automotive maintenance commodities are particularly dangerous if concentrated in groundwater. The discarded items selected for analysis were only positive residue packages (each package could contain either residues or wastes).

The hypothesis, if true, predicts that as income, ethnicity, and family size of a neighborhood changes (as three important sociometric characteristics), the quantities of automotive maintenance commodities discarded will change in a regular fashion. To test this hypothesis, the quantity of automotive maintenance commodities (positive residue packages) were retrieved from the Garbage Project Regular

Sort data (Code 149, see Figure 3). For each of the thirteen census tracts (02, 03, 04, 06, 11, 18, 19, 20, 23, 24, 38, 40, 47) the number of automotive maintenance commodities were counted and formulated into a score.

In addition, a score on the numbers of items found in concentrations of two items or more in a single garbage pickup were compiled for each tract. This score represents the relative concentration of the wastes produced. A high score represents highly concentrated wastes while a low score represents low concentrations of wastes. This is important in understanding how the automotive maintenance activity is performed. High concentrations of commodity containers and their wastes in a single garbage pickup indicate intensive automotive maintenance, including complex and intricate maintenance tasks, while low concentrations indicate much less intensive (and complex) tasks.

These two scores were formulated by taking the actual number for each census tract and weighting them based on the total number of garbage pickups collected from each census tract. From these first two scores (total containers and concentrated containers), a score on the percentage of concentrated containers compared to unconcentrated containers was compiled for each tract. The percentage of packages concentrated is an expression of the relative energy put into maintenance tasks occurring within the tract. The higher the percentage, the more attention household members are personally giving to their automobiles.

These data were entered onto a DEC 10 data file along with data from the 1980 U.S. Census on income, ethnicity, and family size.

Income represents the median income of the household in U.S. dollars compiled for the census tract. Ethnicity was calculated from the percentage of white persons living in the census tract as compared to the total population of the tract. Family size was the household median compiled for the census tract (see Table 4).

SPSS programs Scattergram and Multiple Regression were run on each of the scores with income, ethnicity, and family size as the independent variables and total containers, concentrated containers, and percentage concentrated containers as the dependent variables. The program Scattergram includes the Pearson Product Moment of Correlation statistic (r). This is a "measure of the strength of the linear relationship between two random variables X and Y" (Sinich 1982:402). r is computed as:

$$r = \frac{SSxy}{\sqrt{SSxxSSyy}}$$

Multiple regression analysis employs the method of least squares to fit a general linear statistical model to a set of data. The general linear statistical model relates Y to various independent variables (Sinich 1982:456).

For the regression analyses of total number of automotive maintenance containers none of the equations were significant. This indicates that the variation in total amounts of automotive maintenance containers is not correlated with income, ethnicity, or family size.

The analysis of number of concentrated automotive maintenance containers however, produced two significant equations at the .10

TABLE 5

SOCIOMETRIC CHARACTERISTICS OF THE CENSUS TRACTS

Tract	Income (U.S. $)	Family Size	% White
02	13,307	2.62	29.4
03	7,768	2.43	24.1
04	8,432	1.93	72.4
06	13,304	2.10	89.3
11	11,375	3.38	4.5
18	10,941	1.93	86.0
19	25,136	2.12	86.9
20	14,618	2.73	50.7
23	7,265	3.10	12.1
24	10,724	3.21	16.6
38	12,436	3.62	10.9
40	18,086	2.58	90.7
47	26,264	2.63	93.0

level: concentrated containers with income and family size respectively (see Figures 9, 10). The r^2 value for family size, as the independent variable, is .22639 suggesting that more variation is dependent on family size than income. One of the equations for percentage of packages concentrated was significant at the .10 level and one was significant at the .05 level. Income, as the independent variable, was significant at the .10 level and family size, as the independent variable, was significant at the .05 level. The r^2 values for these two equations were .20840 (income) and .31669 (family size). As can be seen from the scattergrams (see Figures 11, 12) there is some relationship between percent concentrated containers and these two variables. Ethnicity, at least as represented by the percent of white persons, is not highly correlated with percent concentrated containers.

To test the possibility that each of the variables--income, ethnicity, and family size--together affect the relationships with total items, concentrated items, and percent concentrated items, multiple regression analyses were run. In no case, however, did any of the equations prove to be significant even at the .10 level.

The problems of partitioning variance in a small sample population has been discussed above. Despite this, it is quite interesting that income and family size account for such considerable variability in the regression analyses. These results support Hypothesis 2 indicating that these variables are crucial in the estimation of certain commodity container discards and the hazardous wastes associated with them. These results suggest that other activities associated

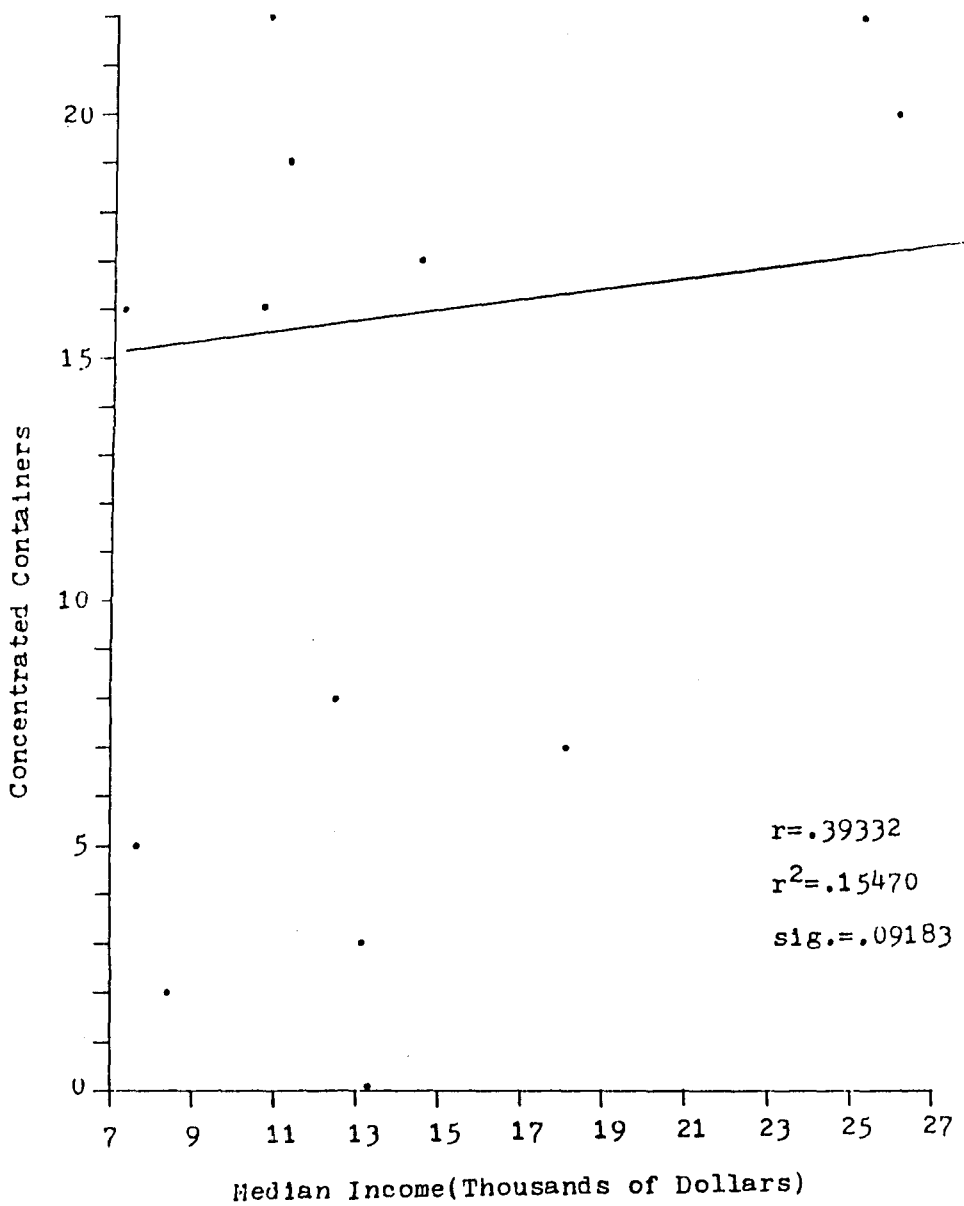

Figure 9: Scattergram of Concentrated Containers With Income

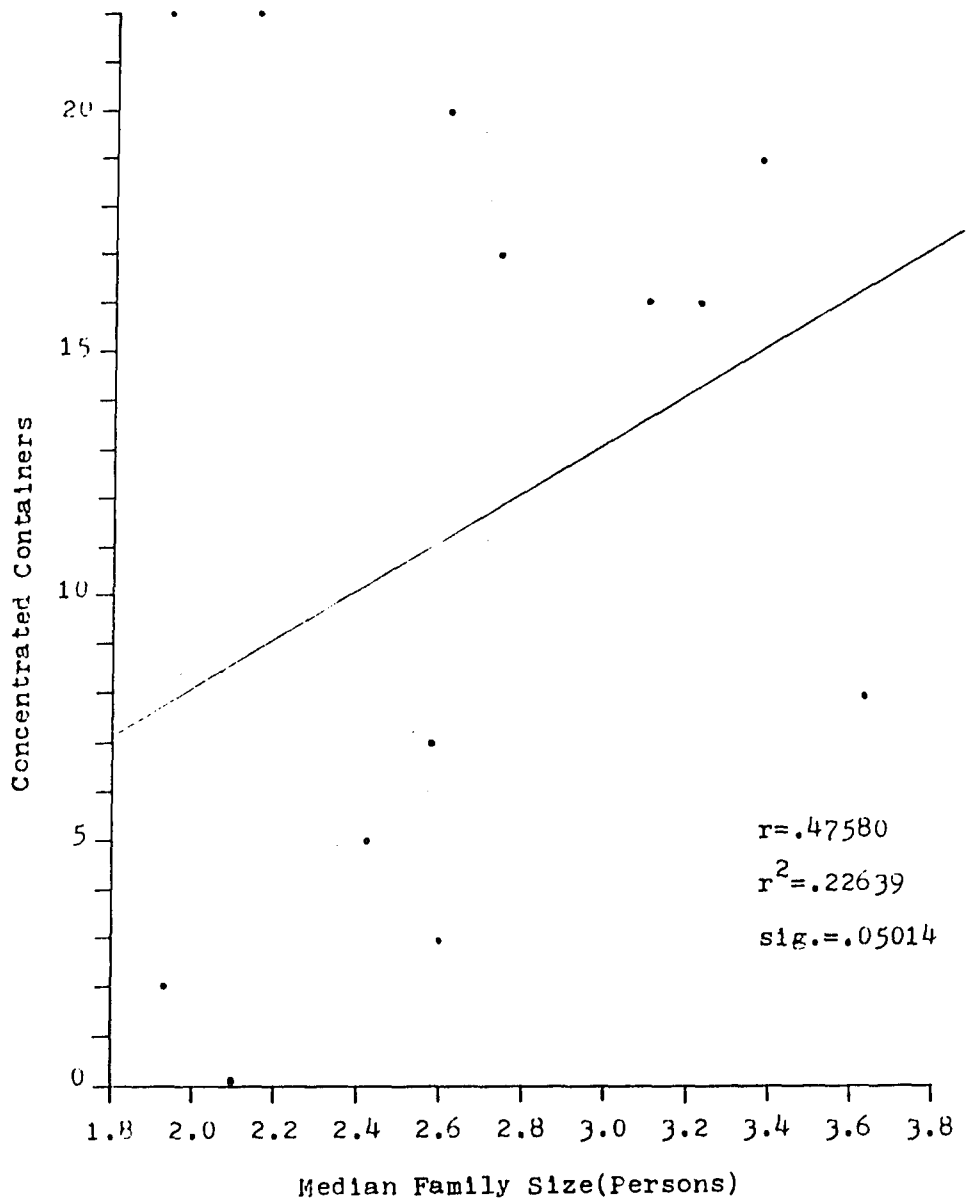

Figure 10: Scattergram of Concentrated Containers With Family Size

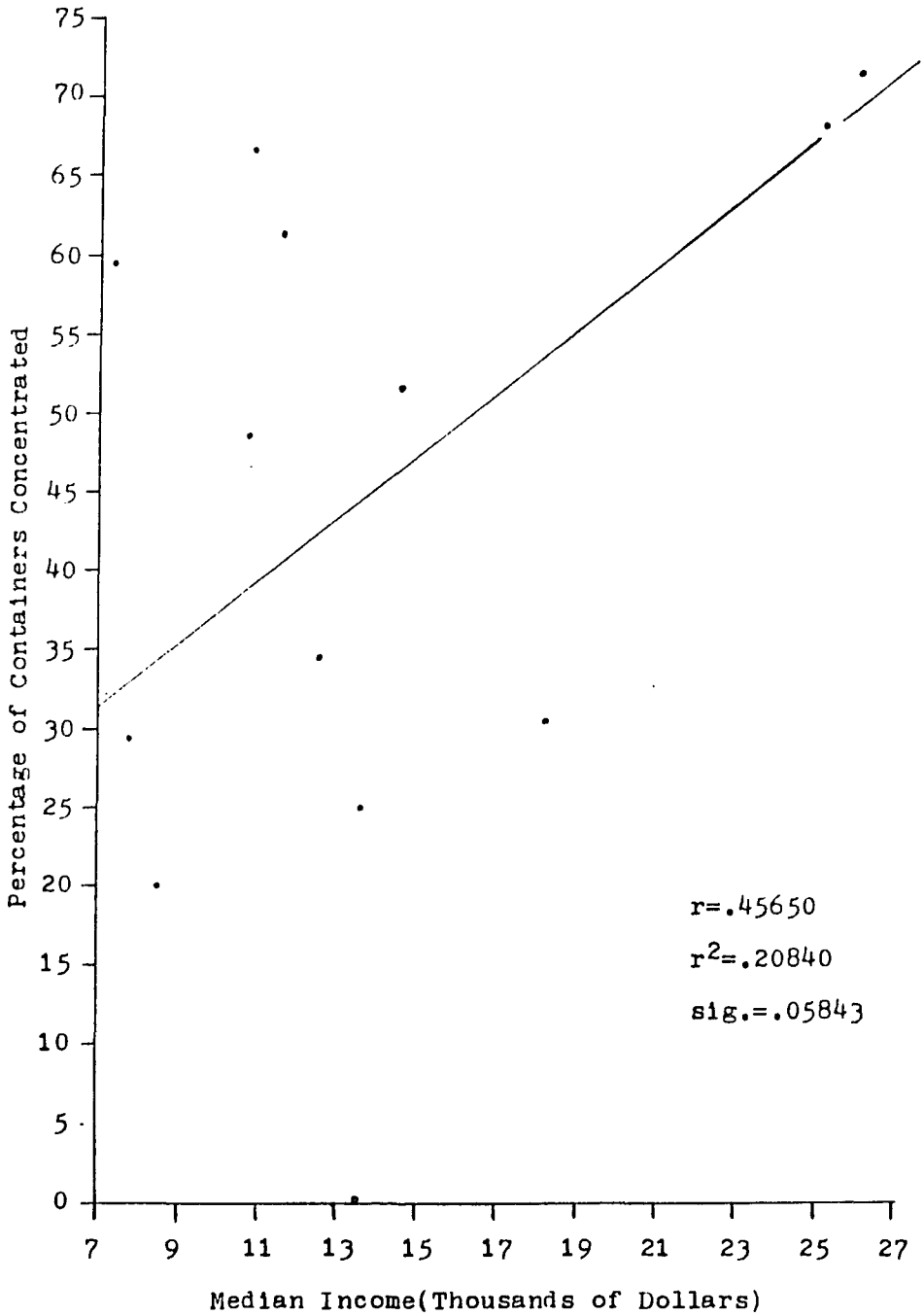

Figure 11: Scattergram of Percentage of Containers Concentrated With Income

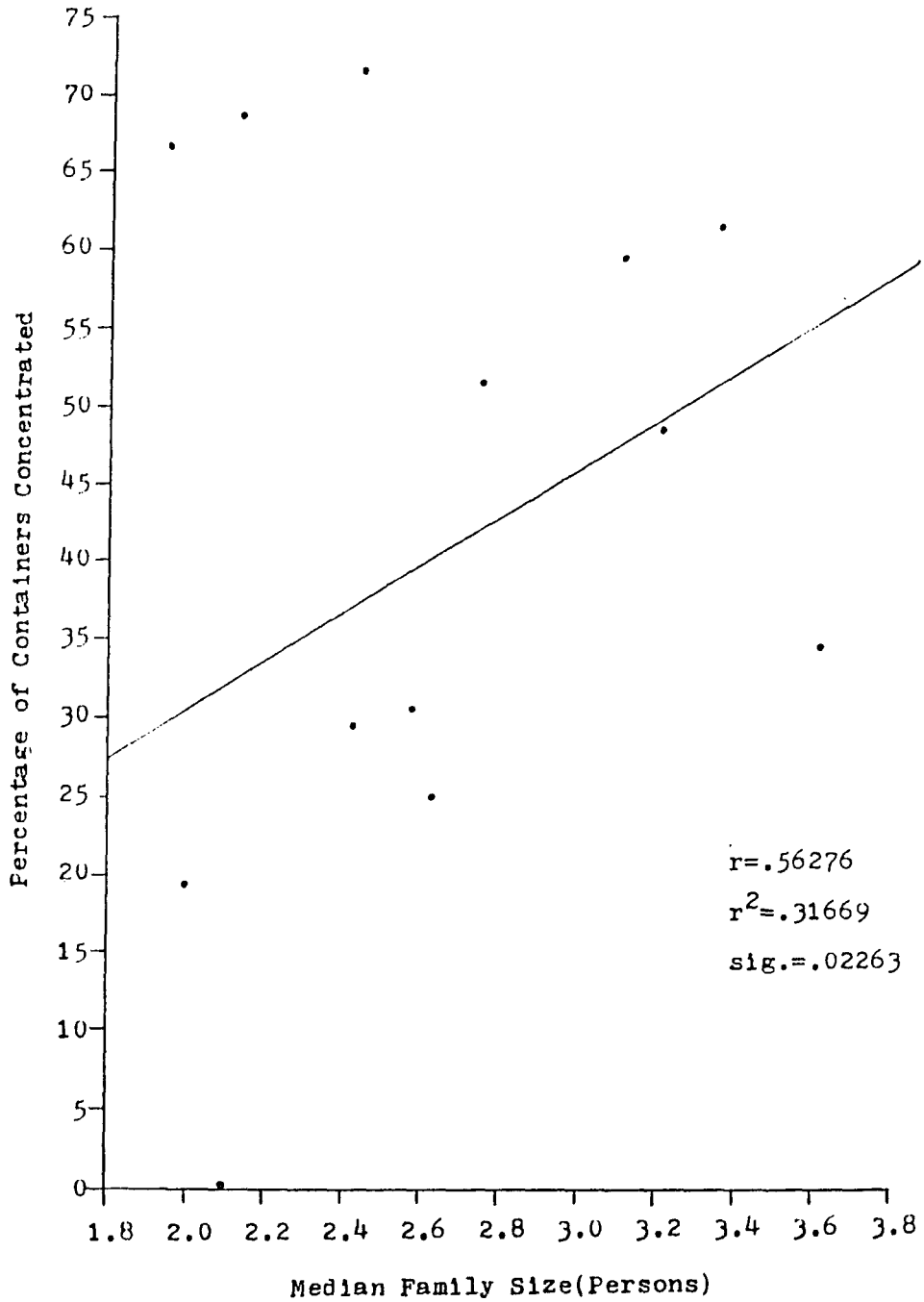

Figure 12: Scattergram of Percentage of Containers Concentrated With Family Size

with the discard of household hazardous wastes may also be affected by neighborhood level behavioral processes.

It is not surprising that income and family size have some effect on how much energy is directly given to automotive maintenance. As a family increases in size, it is more likely to have more adult drivers and possibly more automobiles. It is also more likely that one of these extra drivers will either (1) prefer to do his or her own maintenance or (2) do their own maintenance out of necessity. As income decreases, the replacement funds available for an outside mechanic become less and less. This dictates that households will own less automobiles as income decreases and automobile maintenance activities will also decrease. These behavioral correlates seem to be in some ways reflected in the garbage pickups despite any effects of formation processes and other data limitations.

CHAPTER 5

CONCLUSIONS

The study of household hazardous wastes, including the characterization and evaluation of their effects on the natural environment and human health, is yet in its infancy. This thesis has outlined some of the most important aspects of this study and has suggested three crucial levels of analysis in the generation and discard of these wastes. Two hypotheses regarding two of these levels have been presented and argued for through the analysis of household refuse data. These two levels of behavior--the household, as a generator and discarder of hazardous wastes, and the neighborhood, as a group of culturally related persons sharing ideas, rules, and the general conditions of life, affect how household hazardous wastes are discarded and are crucial to the persons who must regulate and manage solid and hazardous wastes at the third level--the community.

The further characterization of the types, quantities, and concentrations of household hazardous wastes, along with the study of landfill and environmental processes, is crucial for the evaluation of the danger posed by these wastes. Only when these areas have been adequately studied will the safety of our groundwater be assured.

Beyond hazardous wastes, this study has treated many ideas which are used in prehistoric and historic archaeology and cultural

anthropology. The key to estimating and evaluating social inequality in societies (which may relate to political centralization, exchange networks, civilization, and other important levels of social complexity) may lie in the mundane "garbage" of society. Materials that are related to certain important activities--in terms of access to resources, size of family, and the rules and ideas about how things are done, may provide the best cross-cultural and inter-cultural estimates of inequality and other aspects of social complexity.

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