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I am submitting herewith a dissertation written by Margaret V. Douglas entitled "The External Costs to the Carter Community from the Siting of a Municipal Landfill in East Knox County, Tennessee--A Contingent Valuation Analysis." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

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EXTERNAL COSTS TO THE CARTER COMMUNITY FROM SITING A  
MUNICIPAL LANDFILL IN EAST KNOX COUNTY, TENNESSEE  
A CONTINGENT VALUATION ANALYSIS

A Dissertation

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## ABSTRACT

One of the most intense issues in solid waste management is where to site new landfill disposal facilities. With increasing public concern over the risks from landfills, policymakers are being forced to consider the external costs of landfill disposal. The external costs of siting a landfill in a rural Tennessee community were estimated using the contingent valuation method. A personal interview survey was administered to 150 randomly selected households to determine the community's willingness to pay to avoid having a landfill sited in the area. A regression analysis was also performed to determine the relationship between willingness to pay and the socioeconomic characteristics of the population.

The results showed that the average household willingness to pay to avoid a landfill was \$227.00 annually. This can be viewed as the average household cost to residents of the Carter community from having the proposed landfill sited in their area. The most significant explanatory variables of willingness to pay were income, education and perception of risk. The results of this study have implications for a number of public policy issues including local solid waste management strategies, compensation for parties affected by waste siting policies and the benefits of recycling.

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## CHAPTER I

### INTRODUCTION

The United States is leading the world in per capita production of municipal solid waste. The average U. S. citizen generates approximately eight pounds of garbage per day. Additionally, an estimated 110 million tons of industrial wastes and four billion tons of solid wastes from municipal and agricultural operations are generated each year (Bealer, et al., 1982).

Until the mid-1960s, both collection and disposal of solid wastes were considered exclusively a concern of local governments. However, national interest in solid waste disposal has intensified as the associated health risks emerged. Examples of these risks included groundwater contamination from landfill leakage, surface water pollution from runoff, air pollution from incineration, the release of volatile chemicals from ponding and lagooning, as well as the effects from improperly covered landfills (Pye, et al., 1983).

At present, there are three basic methods of disposing solid wastes--landfills, incineration and recycling. The most common disposal mechanism is the landfill which involves the spreading and daily covering of solid wastes with soil according to state and federal regulations. The feasibility of sanitary landfill systems depends on the amount of suitable space available, transportation costs and public acceptance of the disposal site (Bealer, et al., 1982).



There are various types of incinerators which use heat to reduce the volume of solid wastes. The heat generated from incineration can be captured and used as energy to operate the plant or to produce electricity for a local market. Other incineration processes result in the creation of useful by-products such as methane gas and crude oil. However, regardless of the type of incineration, there will be unusable waste residue that must ultimately end up in a landfill. At present, most public policymakers favor increasing landfill capacity over incineration and recycling because the former is assumed to be more cost effective.

The third alternative for solid waste disposal is recycling which can lead to significant reductions in material flow. Recycling conserves raw materials for future use, reduces the volume of solid wastes and prolongs the life of existing landfills. However, since a large volume of waste materials are not recyclable, this option cannot be considered independent of landfills and incineration. As alternative disposal costs rise, recycling will become increasingly more attractive.

Obviously, the three alternatives for solid waste disposal are not independent of each other. Even though increases in incineration and recycling can reasonably be anticipated in the future, the need for additional landfill capacity appears certain. The question with which most communities are faced is where to site the new landfills.

#### Statement of the Problem

Waste disposal practices create external costs when the effects from a producer's activities on other individuals are not internalized



in the producer's costs. For example, in the absence of statutes and regulations pertaining to hazardous waste disposal, the profit maximizing firm would have little incentive to reduce either wastes or public exposure to socially acceptable levels. From an economic perspective, external costs result in an inefficient allocation of resources (i.e., too much wastes and exposure).

There are several options available for a society to mitigate the external costs of landfills. First, the courts can assign property rights and let the parties bargain for a market solution. Alternatively, policymakers could directly control the landfill's activities, fine landfill owners for external effects, subsidize landfill operators to minimize external costs, or provide for compensation to the affected parties (Randall, 1983). Direct control, taxes and subsidies are very difficult to apply to the landfill issue; the technology to monitor and mitigate external effects from landfills is simply nonexistent. Since landfills must be placed somewhere, a more efficient solution might be to encourage bargaining among the effected parties. One option might be for the people who benefit from the landfill to compensate the people who suffer external effects from the landfill. This compensation could be financed by higher garbage disposal fees or special taxes to be used for the compensation fund. The main point is for the cost of the externality to be internalized by the parties who produce it.

To assign these costs, an estimate of the external costs to the community affected by the landfill is essential. The estimated external costs of municipal landfills include the effects of groundwater



contamination, truck traffic, noise, odor, litter and so on. If economists neglect to evaluate these costs, there is no basis from which to compensate those in a community who suffer loss or bear the risk of loss as a result of the waste disposal operations (Havlicek, et al., 1971). Additionally, without considering external costs, policymakers may be mistaken when they assume that increasing landfill capacity is more cost effective than incorporating incineration and recycling into a solid waste management strategy.

Many Tennessee counties and municipalities are currently facing the waste disposal issue as present landfill capacities become depleted (Knoxville News Sentinel, April 17, 1987). In October, 1988, the Tennessee Special Congressional Committee on Hazardous Wastes heard testimony from experts on solid waste in order to develop a statewide strategy for disposing of garbage. Also in October, 1988, the Tennessee Governor's office held a Solid Waste Roundtable to discuss the potential state role in mitigating the "garbage crisis." The most critical need expressed in the meeting was to develop a Tennessee data base on the technical and economic feasibility of the various waste disposal options. In making this decision, the total value of the benefits and costs of the alternatives must be considered to ensure economic efficiency and equity (Randall, et al., 1983).

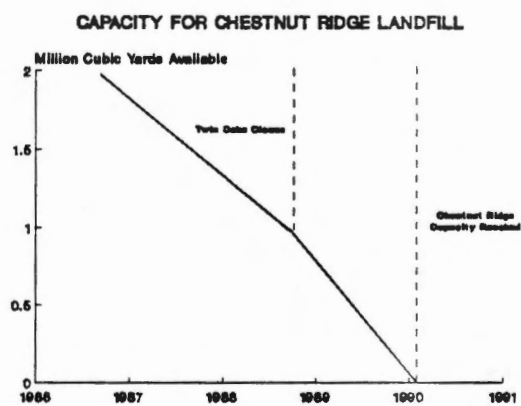
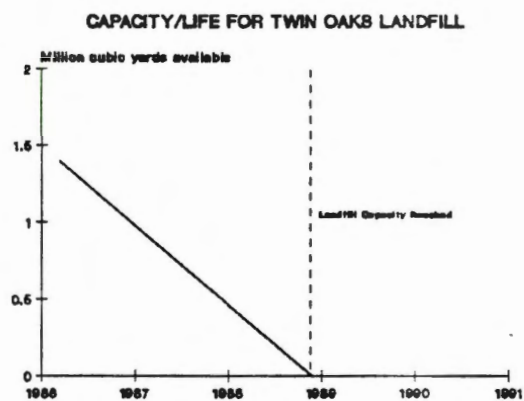
In 1987, the waste disposal issue emerged in Knox County when local administrators considered a request by Browning-Ferris, Inc. (BFI), to site a new landfill in the Carter Community of East Knox County, Tennessee (See Appendix 1. Map of Carter Community and Proposed Landfill Site). Browning Ferris claimed that its Twin Oaks landfill



capacity would be depleted in December, 1988 (Figure I-1). In addition, BFI also projected that the only other landfill available to Knox County would be depleted by 1990 (See Appendix 2. Analysis of Available Landfill Capacity for Knox County, Tennessee). Even though Knox County is considering construction of a mass burn incinerator, it is unlikely that start-up could occur before the advent of a landfill crisis (Figure I-2). In fact, due to local opposition in Knoxville, a possible incineration site in East Knox County was not approved until February, 1989. Incinerator opponents in Knox County say the fight is not over; a law suit may be imminent (Wasserman, 1989). It thus appears that the NIMBY (not in my backyard) syndrome prevails with mass burn incinerators as well as landfills. Even if the incinerator is brought on line, BFI estimated a continuing need for landfill capacity to dispose of over 350,000 cubic yards of refuse and ash per year (Figure I-3).

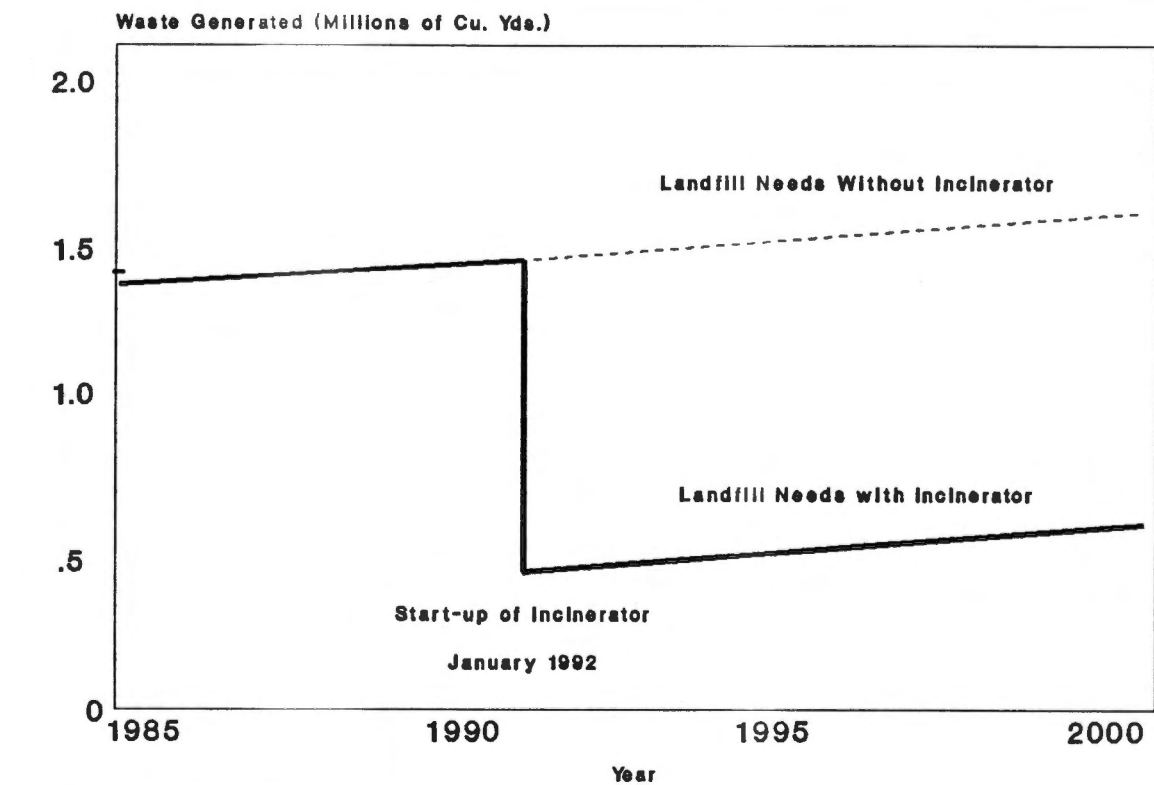
At the request of BFI, the State Department of Health and Environment Geologist, Glenn Pruitt, performed a preliminary geologic investigation of the Carter landfill site on October 31, 1987 (Appendix 3. Report of Geologic Investigation). Pruitt concluded that "the site appeared to be potentially suited for landfill use..." Factors supporting this conclusion were 1) the presence of deep residual soils, 2) moderate to low slopes over most of the site and 3) the absence of surface streams and springs on the site (Knoxville Metropolitan Planning Commission Hearing, February 12, 1987).

After an appeal by the residents of the Carter community, BFI's request to build the landfill was denied by the Knox County Commissioners (See Appendix 4. Chronology of Events in Carter Landfill



Source: Browning Ferris Inc., 1987

Figure I-1. Landfill Availability for Knox County



Source: Browning Ferris Inc. 1987

Figure I-2. Landfill Demands for Solid Waste Generated by Knox County



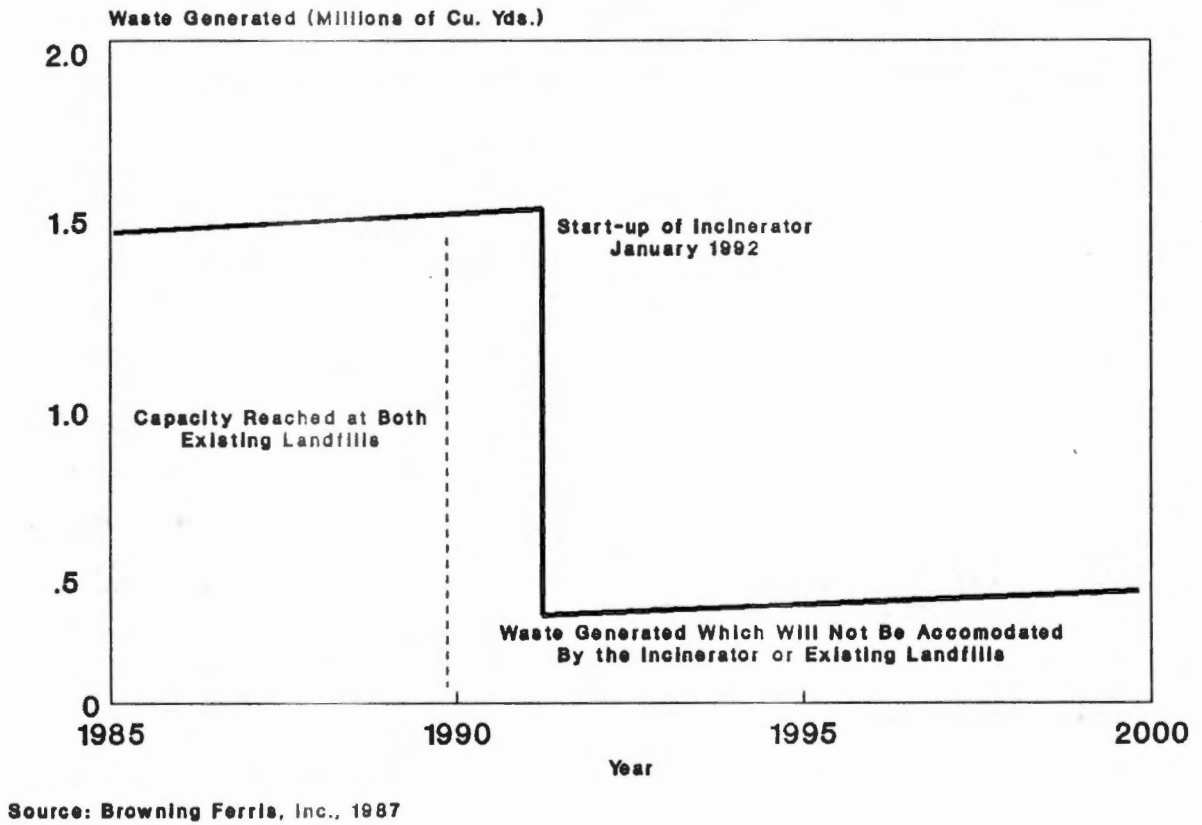


Figure I-3. Knox County Landfill Demands after Closure of Existing Landfills

Case). One of the central issues in the case was the possibility of groundwater contamination from the landfill. The Carter community residents presented testimony from three hydrologists regarding the risks posed by the landfill. All three of the hydrologists were concerned because of the evidence of substantial sinkholes and cave systems under the landfill site (Knox County Commission Hearing tapes, 1987). John McCormack, retired Chief Geologist for ASARCO, Inc., stated:

The karst geological features in the Carter Community render the groundwater system very susceptible to contamination. With karst terrains, the limestone and dolomite formations beneath the soil develop cracks and holes over time, forming huge underground caves and channels. These cracks and opening can extend great distances to municipal and private wells. When a landfill is situated in a karst area, it is just a matter of time until the leachate from the landfill seeps into the groundwater system (Metropolitan Planning Commission hearing minutes, March 12, 1987).

Even though BFI's request was denied, Knox County still faces the decision of where to locate a landfill to meet future demands for waste disposal. If Knox County administrators decide to allow development of the Carter landfill, they may want to stipulate that BFI or Knox County residents compensate the affected parties for the external effects caused by the landfill.

Baumol and Oates (1975) note that the study of the distributive effects of environmental policy is still in its infancy despite the crucial importance of the equity issue for environmental policy. They raise the possibility that the less affluent may believe that environmental improvements come at their expense. Baumol and Oates cite poll data as evidence for a "consistent pattern of disproportionately

strong support for environmental programs among higher income groups" (Baumol and Oates, 1975:184).

Mitchell and Carson (1985) also suggest that the monetary benefits of environmental policies are subject to strong income and socioeconomic constraints. Policymakers have been reluctant to move from the status quo toward incentive-compatible environmental improvements without detailed information about the gainers or losers from a policy change (Mitchell and Carson, 1985). Therefore, in determining the costs of an externality or the benefits of internalizing these costs, it would also be politically important to determine the relationship between the socioeconomic characteristics of the affected population and the magnitude of the external cost.

Due to the concern for groundwater quality near the proposed BFI landfill, an analysis of the costs of providing safe drinking water to the residents of the Carter community would also be useful to policymakers. If the BFI request for a permit to build the Carter landfill is approved, policymakers may stipulate that residents be guaranteed a safe source of drinking water, such as bottled or piped water. It should be emphasized that this value would represent a lower bound estimate of external costs from the proposed landfill since other external costs would not be included in the cost of providing a safe drinking water source.

### Objectives

1. Estimate the external costs to Carter community residents if the BFI proposed landfill is approved.

2. Describe the Carter community population and determine the relationship between the socioeconomic characteristics of the population and the level of social costs estimated to be incurred by community residents.
3. Estimate the costs of providing piped water to the Carter community.

To meet Objective 1, the contingent valuation method (CVM) will be used to determine the Carter community residents' willingness to pay to avoid a landfill in their area. In Chapter II, the nonmarket valuation literature will be reviewed so the appropriateness of the CVM approach can be demonstrated. Possible bias issues associated with CVM surveys will be addressed as well as techniques for minimizing these biases. In Chapter III, the following will be addressed: the economic theory inherent in CVM studies; the methodologies for satisfying Objectives 2 and 3; and the Carter community CVM survey. The results will be analyzed in Chapter IV. Finally, in Chapter V, a summary of results, policy implications and limitations of the study will provide a conclusion.

## CHAPTER II

### REVIEW OF LITERATURE

#### External Costs

The external (nonmarket) costs of municipal landfills include human health risks, damage to ecosystems, loss in property values and aesthetic enjoyment. A major issue in environmental benefit-cost analysis is how to conceptualize and evaluate these external costs (Boyle and Bishop, 1985). Many costs are not easily identified, quantified and monetized (Fisher, 1985). As a result, most studies in the past have ignored external costs that represent the loss of environmental amenities that are not traded in the marketplace. Recent studies in valuing wildlife and other environmental amenities have included nonmarket values in the analysis (Brookshire, et al., 1981; Seller, et al., 1985; Schultze, et al., 1981; Smith, et al., 1983; Walsh, et al., 1984).

External costs can be evaluated in terms of use and nonuse values foregone. Nonuse values consist of "existence" and "option" values. Existence values were first suggested by Krutilla (1967), who reasoned that many people may value an environmental asset even though they may never use the resource in question. Several authors have argued that the basis for existence value is altruism (Boyle and Bishop, 1985; McConnell, 1983; Randall and Stoll, 1983). For example, a person may hold existence values out of a desire to bequest a natural resource to future generations, from a desire to be benevolent to other human

beings, out of a concern for the ecosystem or other motivations of an altruistic nature.

Option values were first introduced by Weisbrod (1964) but have been refined and clarified (Bishop, 1982; Freeman, 1979; Graham, 1981; Smith, 1983). Option values arise when people are uncertain about the future. For example, an individual might be uncertain as to whether a landfill would contaminate his/her drinking water supplies. Option values are a subjective adjustment of resource values to reflect uncertainty (Smith, September, 1987).

In the early 1980s, Raucher (1983) used a damage-avoidance approach to estimate the value of avoiding a groundwater contamination incident from waste disposal sites. The basic premise of Raucher's approach was that the value of reducing the probability of contamination (expected human suffering from such an incident) is at least as great as the expected costs of restoration, containment or avoidance if the incident were allowed to occur (Schechter, 1983 and 1985).

Raucher (1983) emphasized that the benefit figures derived by this approach must be interpreted as lower bound estimates of the value of protecting groundwater. This is because the damages avoided approach estimates the use value of protecting groundwater and omits other nonmarket benefits such as option and existence values.

#### Techniques for Evaluating External Costs

There are currently three techniques available for inferring the value of a nonmarket amenity: the travel cost method (TCM), hedonic price analysis and the contingent valuation method (CVM). The TCM was

first proposed by Hotelling (1949) as an approach to estimating the demand for a recreation site. The TCM is a method of estimating the demand for a recreation site which uses travel costs as a proxy for a nonexistent market price (Clawson, 1959). The TCM is applicable to specific recreational sites but cannot be applied to environmental amenities where travel costs are not relevant (a municipal landfill).

In general, hedonic price analysis uses changes in property values as a proxy for the external costs of pollution (Fisher and Raucher, 1984; Havlicek, 1972; McDougall, 1980). However, Maler (1977) argued that the underlying assumptions of property-value models are unrealistic (e.g., the assumption of full information), and Lave (1972) argued that property values are inadequate and merely offer a substitute method of estimating health-damage functions. It is also questionable as to whether property values represent all benefits of protecting an environmental resources (e.g., benefits to wildlife, vegetation and future generations).

The choice of a valuation method is predicated to some extent on whether the components of value should be estimated separately and then aggregated to obtain a measure of total value or whether total value is to be estimated directly. The more emphasis there is on measuring total values in general, and nonuse values in particular, the more dependent the researcher is on contingent valuation (Randall, et al., 1974).

In the CVM survey, a hypothetical market is set up and respondents are asked to indicate one of two values: the maximum amount of money they would be willing to pay to ensure specified levels of environmental quality or the minimum they would be willing to accept for

a reduction in environmental quality (Freeman, 1986; Mitchell and Carson, 1985; Randall, et al., 1974). The CVM was developed by Davis (1963) to estimate the value of big game hunting in the Maine woods. Randall, et al. (1974), refined Davis's approach and used the CVM to value visibility in the Four Corner region of New Mexico. Since these studies, the technique has been subjected to extensive professional criticism and, as a consequence, has been considerably improved (Brookshire, et al., 1981; Bishop, et al., 1984; Randall and Stoll, 1983).

Most of the criticism of the CVM focuses on survey administration and design problems (Cummings, et al., 1984). However, the most purported weakness is that it is generally not possible to observe whether people would actually pay their stated amount for the change in environmental quality (Bishop, et al., 1984; Freeman, 1986). The hypothetical nature of the CVM could lead respondents to bid carelessly, thereby generating unreliable value data. Bishop and Heberlein (1979) speculate that CVM systematically understates willingness to pay and systematically overstates willingness to accept.

#### Bias Issues

Carson (1985) notes three sets of questions that have been of primary concern for economists involved in CVM research: 1) the strategic bias question; 2) questions related to questionnaire design (starting point, vehicle or mode of payment and informational bias); and 3) questions concerning the equivalence between willingness to pay (WTP) and willingness to accept (WTA) values derived from the CVM. To improve

the efficiency of CVM studies, research methods have been examined to minimize these biases.

### Strategic Design

Concern with strategic behavior on the part of respondents is based on the possibility that a respondent may try to influence the outcome of a study by incorrectly stating his/her WTP or WTA. For example, if an individual thought that he/she might really have to pay the stated amount, then there may be an incentive to understate WTP. On the other hand, respondents might inflate their WTP value if they felt the possibility of compensation was real (Cummings, et al., 1986).

Brookshire, et al. (1976), developed a test for strategic bias based upon the following arguments. Consider the individual whose "true" bid is different (either higher or lower) from those of the other subjects. In order to behave strategically, a substantially large false bid (relative to the sample mean bid) would have to be given to influence the overall sample mean bid. Given the assumption that "true bids" are distributed normally, the "Brookshire test" of strategic bias involves inspection of the actual bid distribution. As illustrated by Figure II-1, the greater the occurrence of strategic bidding, the flatter the distribution of bids. In other words, if the CVM bids include a large number of zero and high bids, thereby producing a "flat" distribution of bids, strategic behavior is assumed to exist.

Mitchell and Carson (1985) used a similar approach to test the presence of strategic bias in their national water quality survey. However, their approach differed from that of Brookshire, et al. (1986).

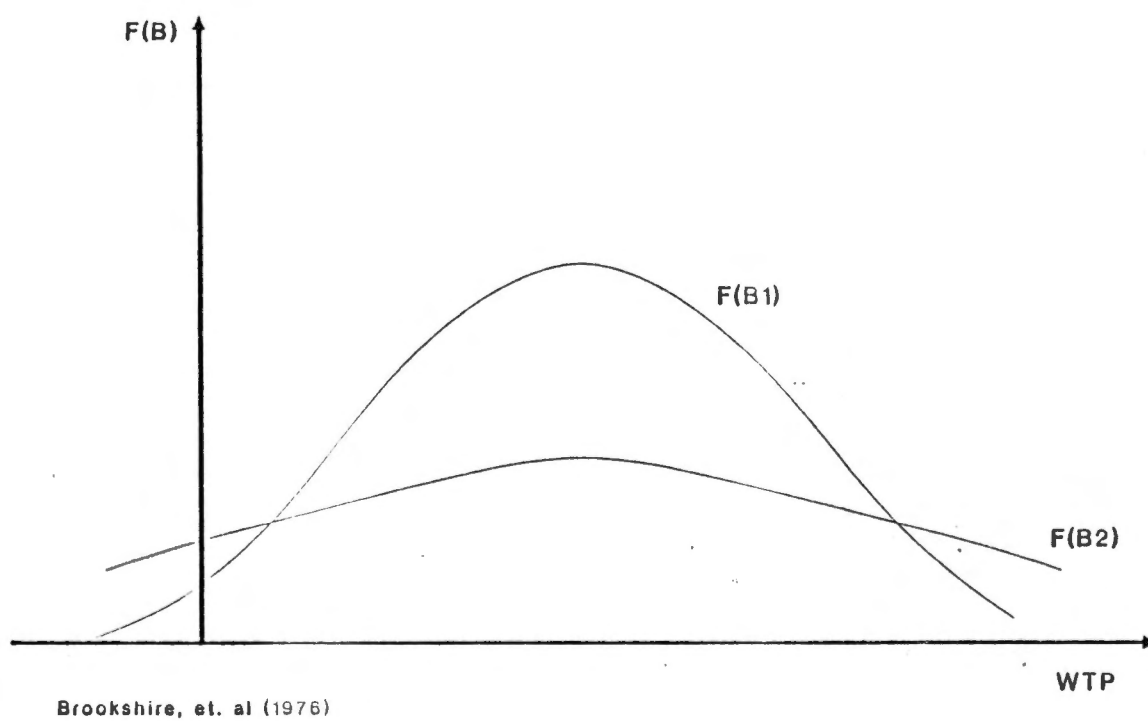


Figure II-1. Examples of WTP Distributions

Mitchell and Carson 1985) used the average U. S. income distribution as a "normal" distribution in an analysis concerning the flatness of the distribution of bids from a CVM. In their Lake Powell study, the overall shape of the bid distributions was not flat; it actually approached a log normal distribution. Thus, the Mitchell and Carson study would indicate that CVM surveys do not necessarily result in strategically biased bids that are correlated with the distribution of incomes.

### Questionnaire Design

There are three types of biases which can result from CVM questionnaire design. Starting point bias is possible in a questionnaire where respondents are asked to respond "yes" or "no" to the question of whether they would pay or accept a specific dollar amount for a change in an environmental amenity. Randall (1983) identified two possible sources for starting point bias. First, the starting bid may influence the respondent's range of appropriate bids or costs. Thus, the individual might respond differently depending on the starting point. Secondly, a lengthy bidding process could bore or irritate the respondent, resulting in inaccurate bidding.

Several studies have analyzed the effects of alternative starting points on starting point bias (Brookshire, et al., 1982; Brookshire, et al., 1981). Although Samuelson (1955) and other economists have expressed concern about the possibility of obtaining "true" individual valuations of nonmarket goods due to strategic behavior, most results from the research to date do not show evidence of starting point bias in

CVM studies, even when iterative bidding approaches have been used (Cummings, et al., 1986).

The CVM researchers have also given considerable attention to vehicle bias (i.e., the potential bias that is associated with the choice of a mode of payment). For example, payments for providing an improvement in environmental quality could hypothetically be made via taxation, user fees, utility bills, trust funds or simply higher prices for goods and services (Cummings, et al., 1986). Vehicle bias is usually detected in one of two ways. First, it has been argued that vehicle bias is indicated when either mean bids or the recorded observation differs significantly with the choice of vehicle (Brookshire, Randall and Stoll, 1981). Secondly, Cummings, et al. (1985), argue that payment vehicles that allow individuals to substitute over a wide range of commodity purchases, result in higher CVM bids. Although there is no systematic method one might use to eliminate such biases, Arrow and Randall suggest that the CVM's mode of payment should be based on realism; i.e., use of the payment vehicle that would most likely be employed if the environmental amenity were to be provided (Cummings, et al., 1985).

The third type of questionnaire design bias is informational bias. Contingent valuation methods can be biased when some subjects are given more or less (quantitatively or qualitatively) information than other subjects. As Randall and Stoll (1983) point out, the problem lies in the fact that two sets of information imply two different market structures or two different commodities. To minimize this possible bias, it is suggested that pretests of the questionnaire be used to

ensure a balance between informational needs with the subject's capacity to absorb the information. When the relevant set of information that respondents need to make CVM bids is determined, it should be applied consistently to each subject (Randall and Stoll, 1983).

#### Willingness to Pay vs. Willingness to Accept Methods

Since WTP and WTA are simply different ways to measure the value of consumer surplus, economic theory establishes the argument that they should be approximately equal. However, empirical research suggests that in CVM surveys where both measures are used, the results demonstrate large differences between average WTP and WTA. To date, researchers have been unable to explain the observed differences between the two measures (Carson and Mitchell, 1984). Contrary to what one might logically expect, past studies have shown that income differences between groups of subjects are generally not large enough to warrant the attribution of WTP-WTA differences to an income effect (Cummings, et al., 1985). At this point, all that can be said is that differences in WTP and WTA measures persist in CVM results. Most CVM studies have opted for the WTP approach (Edwards, 1987; Brookshire, et al., 1985; Carson, 1985; Mitchell and Carson, 1985; Cummings, et al., 1984; Walsh, 1984; Desvousges, et al., 1983; Hoehn and Randall, 1983). From a pragmatic standpoint, the WTP measure might be a more acceptable measure since it has not shown a bias to overstate the value of the nonmarket commodity.

Hoehn and Randall (1983) have examined the incentives implicit in contingent valuation surveys and concluded that in a Hicksian

compensating value framework no incentives exist for overvaluation of policy changes. While there is no doubt that designing a meaningful and unbiased CVM survey is a challenging task, Randall (1983) argues that "contingent valuation works better than most economists might have expected." Smith, et al. (1986), point out that if careful procedures are followed to develop the questionnaire, to select the sample and to obtain the completed interview, then respondents will be able to objectively value reductions in their risks to hazardous wastes.

The U. S. Water Resources Council (1979) approved the contingent valuation method as an acceptable procedure for estimating the economic value of environmental resources. The interagency committee established procedures for surveying a sample of the population about maximum willingness to pay (WTP) for changes in the availability of an environmental amenity, such as a wilderness. The value reported is assumed to correspond to the point of indifference between having the amount of income reported or the level of environmental amenity.

Valuation questions posed in contingent markets are generally of two types: open- or closed-ended (Bishop and Heberlein, 1979; Sellar, et al., 1985). In the case of close-ended (binary-choice) questions, the respondents are asked to accept or reject a specified dollar amount for their WTP or WTA (Boyle and Bishop, 1985; Edwards, 1987; Hannemann, 1984). With open-ended WTP questions, the participant is asked to determine the most he or she would pay for a change in an environmental amenity. As a reference point, the participant is given information on typical annual payments for other services such as police and fire

protection, education, and sewage fees (Edwards, 1987; Greenley, et al., 1981).

Boyle and Bishop (1985) report that there is no significant difference between valuations collected from binary-choice questions and open-ended questions. Edwards (1987) used both methods in his Cape Cod CVM survey on groundwater contamination from municipal sewage. Mitchell and Carson (1985) assert that both types of CVM valuation are reliable for measuring nonmarket values as long as the questions are consistent with relevant economic theory and understandable to the respondent.

## CHAPTER III

## METHODOLOGY

Economic Theory

The theoretically appropriate welfare measure for evaluating a change in an environmental amenity is the Hicksian compensating surplus, a measure of willingness to pay for the change in welfare (Hoehn and Randall, 1983; Randall and Stoll, 1980). The modeling of this process is based on microeconomic theory of utility maximization (Varian, 1978):

The value that a person places on an environmental amenity is reflected in the person's utility function:

$$U = U(X, Q) \quad (1)$$

where:

$X$  = vector of quantities of private goods; and

$Q$  = the level of environmental quality with the landfill.

Assume initially that BFI has permission to build the landfill in the Carter community, resulting in environmental quality of  $Q$  and utility of  $U^0$ . Now consider the policy option to restrict the landfill (i.e., change  $Q$  to  $Q'$ ). To value this change, one could look at the associated dual minimization problem for the utility function given in (1). The objective in the dual is to minimize total expenditures needed to maintain a given level of utility. In the Carter landfill case, the dual solution would be the minimum expenditure needed to keep the residents at  $U^0$  if the landfill was prohibited. In economic theory, the expenditure minimization problem would be:

$$\text{minimize } \sum_{i=1}^n P_i X_i \text{ subject to } U^0 = U(X, Q'), \quad (2)$$

where:

$P_i$  = price of private good  $i$ ; and

$X_i$  = quantity of private good  $i$ ; and

$X$  = vector of quantities.

The solution to this problem is an expenditure function  $E$ :

$$E = E(P, Q', U^0). \quad (3)$$

This minimum level of expenditures defines the consumer's postpolicy income level necessary to keep the consumer indifferent to the landfill (Varian, 1975). In this case,

$$E(P, Q', U^0) = M', \quad (4)$$

where:

$M'$  = income level after policy decision to prohibit the landfill holding

$U$  at  $U^0$ ; and

$$W = W(P, M', Q'); \quad (5)$$

where  $P$  is a vector of prices.

This is the indirect utility function defined by the dual utility maximization problem (Varian, 1978).

Thus, the solution to the expenditure minimization problem given in (2) gives the minimum post-policy level of income,  $M'$ , needed to maintain the consumer's initial utility level given the change in  $Q$ . The  $i$ th consumer's annual willingness to pay for the change in  $Q$  can be defined as:

$$V_i = M^0 - M',$$

where:

$M^0$  = consumer's level of income with the landfill; and

$M'$  = level of income after the consumer has paid to avoid the landfill.

The aggregate value of the Carter community's annual willingness to pay is thus:

$$V = \sum_{i=1}^n V_i, \quad (6)$$

where  $n$  is the number of households in the Carter community.

Assume that the value to the Carter community of not having a landfill (i.e., the external costs of the landfill) can be viewed as a time stream:

$$V(t),$$

where  $t$  indicates time.

If  $V(t)$  is the aggregate value of  $V_i(t)$  for the Carter population at time  $t$ , the present value of avoiding the landfill is:

$$P_0 = \int_0^{\infty} V(t) e^{-rt} dt, \quad (7)$$

where:

$r$  = rate of discount; and

$P_0$  = the present value of the external costs generated by the landfill if it exists at  $t = 0$ .

### Regression Model Specification

Annual willingness to pay was hypothesized to be a function of 10 socioeconomic characteristics. The following model was specified to represent this relationship:

$$V_i = f(S_j) + e_i, \quad i = 1 \dots n, \quad j = 1 \dots 10$$

where:

$S_j$  = represents the following socioeconomic variables:

1. INC (annual household income).
2. EDU (education of respondent).
3. AGE (age of respondent).
4. SEX (sex of respondent).
5. NIH (number in household).
6. HOM (ownership of household).
7. DWS (dependence on well water as a drinking source).
8. YIC (number of years residence in the Carter community).
9. MFL (miles from landfill).
10. POR (perception of risk from the landfill).

### Estimated Cost of Piped Water

The estimated cost of providing district piped water to the Carter residents who are presently dependent on well or spring water for drinking supplies will be calculated as follows. The percentage of households using well water will be inferred from the sample population responses in the CVM survey. The estimated capital costs of hooking-up

to the district water lines will be amortized over 50 years to get an annual value. The annual water bill for a typical household in the Carter community will be determined from Knoxville Utility Board data. The average annual capital and operating expenses of piped water for the typical household will be multiplied by the estimated number of households in the Carter community presently using well or spring water to derive total annual costs to Carter community residents of switching from well water to district water.

#### Carter Community Survey Design

The technique used to sample the Carter community population is called area probability sampling (Carson, 1985). This is a procedure which produces an accurate, current and convenient sampling frame. All individuals in the study area have a known probability of selection and each person can be identified as a member of only one household.

The Carter population was defined as encompassing four Knox County tax maps (numbers 62, 63, 73, 74). The estimated population size of 800 households was derived by reviewing property records for the Carter population in the Knox County Tax Assessors Office. The geographical size of the area (the four tax maps) was approximately eight square miles encompassing the proposed Carter landfill.

There is no consensus in the literature as to whether personal interview CVM surveys are more effective than CVM mail surveys; therefore, two pretests were performed on the Carter population to determine the most appropriate method of eliciting responses from the sample households. In the first pretest, 10 randomly selected

households were given questionnaires and asked to complete and return the forms by mail in an addressed, stamped envelope. An additional 10 randomly selected households were personally interviewed in the second pretest. The results of the pretests clearly indicated that respondents were able to understand and reasonably respond to the questionnaire when administered personally, while the 70 percent of those in the mail pretest did not respond or responded incorrectly to the survey. Thus, the researcher elected to personally interview the respondents in the Carter landfill study.

Since the objective of the survey was to obtain household willingness to pay, the contingent market in the questionnaire was personally explained to the respondent with the request that the head of household or both spouses jointly determine the WTP value. As Smith and Devoucher (1986) suggested, careful consideration was given to ensure that respondents were able to understand and evaluate the hypothetical environmental amenity in the contingent market.

In an effort to minimize starting point bias, the researcher elected to use an open-ended question rather than a bidding procedure to elicit WTP values. To aid them in understanding and relating to the contingent market respondents were given payment cards as developed by Carson, 1985 (see Appendix 5. Survey Questionnaire for the Carter Landfill Study). For different levels of income, respondents circled a value from zero to a predetermined number indicating their willingness to pay to avoid a landfill near their residence.

Also, as a result of the pretest, the researcher felt that respondents could relate more realistically to a monthly rather than

annual WTP bid. Using this approach, most respondents seemed to view their WTP bid as a hypothetical monthly payment for an additional utility service. As suggested by Randall (1984), this effort to make the contingent market more realistic minimizes possible vehicle bias.

In a further effort to minimize vehicle bias, respondents were told that their hypothetical WTP value would be made in the form of higher prices for garbage service. Due to the traditionally conservative nature of most East Tennessee communities, this vehicle of payment was felt by the researcher to be more acceptable than a tax or user fee scheme.

Finally, to mitigate the possibility of upward strategic bias, the WPT as opposed to the WTA measure was used to determine the Hicksian compensating surplus (the social cost of the landfill to the Carter community). To check for strategic bias, the Brookshire test (1976) will be applied to the distribution of WTP values to determine whether they are "true" bids.

## CHAPTER IV

## RESULTS

Frequency Distribution of Household WTP Bids

The frequency distribution of WTP bids is shown in Table IV-1. The actual WTP bids appear to be distributed normally; however, there is a relatively large number of zero bids which indicates that some strategic bidding may exist.

When respondents offered a zero bid, they were asked to indicate the reason for their choice (see Appendix 5. Survey Questionnaire for the Carter Landfill Study). Twelve respondents answered, "I cannot afford to pay anything," while seven respondents "did not believe there was a danger from landfills." These bids were accepted as "true bids." Other responses (nine "object in principle" and one "moving away") were viewed as protest or irrelevant bids and were excluded from the analysis. The question which remains is how many of the assumed "true bids" were actually strategically false bids. One may hypothesize that considering the relatively large number of zero bids and the fact that WTP was used rather than WTA, the value of external costs estimated from this study is a conservative estimate.

Frequency Distributions for Explanatory Variables

The frequency distributions for the variables which are hypothesized to explain the Carter community's willingness to pay to avoid a landfill are shown in Table IV-2. These distributions provide

Table IV-1. Frequency Distribution of Household Willingness to Pay to Avoid a Landfill in the Carter Community, 1988

| Range of Annual Household WTP | Number Reporting | Percent    |
|-------------------------------|------------------|------------|
| 0                             | 19               | 13.8       |
| 1-24                          | 4                | 2.9        |
| 25-49                         | 9                | 6.5        |
| 50-74                         | 23               | 15.9       |
| 75-99                         | 17               | 12.3       |
| 100-199                       | 26               | 18.8       |
| 200-499                       | 23               | 15.9       |
| 500-999                       | 8                | 5.8        |
| 1,000-1,499                   | 7                | 5.1        |
| 1,500-2,000                   | <u>4</u>         | <u>3.0</u> |
|                               | 140 <sup>a</sup> | 100.0      |

<sup>a</sup>Ten responses rejecting the payment vehicle were removed from the analysis.

Table IV-2. Mean Willingness to Pay and Frequency Distributions for Explanatory Variables

| Variable            | Category | Description             | Mean<br>WTP | Number<br>Reporting | Percent |
|---------------------|----------|-------------------------|-------------|---------------------|---------|
| Number in household | NIH1     | one to two              | 231         | 53                  | 38      |
|                     | NIH2     | three to four           | 225         | 68                  | 49      |
|                     | NIH3     | five to six             | 262         | 15                  | 10      |
|                     | NIH4     | > six                   | 58          | 4                   | 3       |
| Age                 | AGE1     | < 35                    | 184         | 22                  | 16      |
|                     | AGE2     | 36 to 45                | 355         | 39                  | 28      |
|                     | AGE3     | 46 to 55                | 289         | 21                  | 15      |
|                     | AGE4     | 56 to 65                | 218         | 37                  | 26      |
|                     | AGE5     | > 65                    | 108         | 21                  | 15      |
| Sex                 | SEX      | 0 = male                | 265         | 73                  | 52      |
|                     |          | 1 = female              | 185         | 67                  | 48      |
| Income              | INC1     | < \$10,000              | 40          | 27                  | 19      |
|                     | INC2     | \$10,000 to \$19,000    | 103         | 56                  | 40      |
|                     | INC3     | \$20,000 to \$29,000    | 139         | 26                  | 19      |
|                     | INC4     | \$30,000 to \$49,000    | 515         | 27                  | 19      |
|                     | INC5     | \$50,000 and over       | 1,825       | 4                   | 3       |
| Education           | EDU1     | some high school        | 46          | 27                  | 19      |
|                     | EDU2     | high school graduate    | 88          | 57                  | 40      |
|                     | EDU3     | some college            | 181         | 26                  | 19      |
|                     | EDU4     | college graduate        | 445         | 27                  | 19      |
|                     | EDU5     | some graduate school    | 1,700       | 3                   | 3       |
| Homeownership       | HOM      | 0 = rent                | 20          | 9                   | 6       |
|                     |          | 1 = own                 | 241         | 131                 | 94      |
| Years in community  | YIC1     | < one year              | 27          | 9                   | 6       |
|                     | YIC2     | one to five years       | 362         | 25                  | 18      |
|                     | YIC3     | six to 15 years         | 302         | 40                  | 29      |
|                     | YIC4     | 15 years or more        | 157         | 66                  | 47      |
| Drinking water      | DWS      | 0 = well or spring      | 418         | 41                  | 29      |
|                     |          | 1 = district or bottled | 147         | 99                  | 71      |
| Miles from landfill | MFL1     | adjacent to one mile    | 381         | 47                  | 34      |
|                     | MFL2     | one to two miles        | 151         | 9                   | 6       |
|                     | MFL3     | > two to three miles    | 159         | 40                  | 29      |
|                     | MFL4     | > three miles           | 139         | 44                  | 31      |
| Perception of risk  | POR      | 0 = high                | 262         | 121                 | 86      |
|                     |          | 1 = none                | 0           | 19                  | 14      |

descriptive information about the socioeconomic characteristics of the Carter community. Approximately one-half of the sample was female. The modal respondents in the survey were between 36 and 45 years or 56 and 65 years of age, had received a high school education and had lived in the community for more than 15 years. The majority of the households had three to four family members with a household income of between \$10,000 and \$19,000. Homeowners represented 94 percent of the sample, with a majority of the households dependent on district water as a drinking source.

Of those households surveyed, 86 percent perceived a "very high" health risk associated with the siting of a landfill in the Carter area. Those perceiving a high risk were also the 86 percent of the respondents who were willing to pay to avoid the landfill. It should be noted that the survey question regarding perception of risk offered four possible answers (see Appendix 5. Survey Questionnaire for the Carter Landfill Study). All respondents were either very concerned or did not foresee any risks from the landfill. The other two possible responses were not chosen.

Also shown in Table IV-2 are the mean willingness to pay values for each explanatory variable. As might be expected, the mean WTP was positively related to levels of income and education. The average WTP for the AGE categories showed that younger and older respondents were willing to pay less than those between the ages of 36 and 65. Males were willing to pay an average of \$80 more per year than females. Those respondents who owned their homes or were dependent on well water as a drinking source were, on the average, willing to pay considerably more

than renters and those not dependent on well water for drinking supplies.

The average willingness to pay did not vary appreciably between households with six or less family members. However, mean WTP decreased considerably when the number in household was greater than six. The WTP value for years in community (YIC) proved to be an unexpected result. On the average, the residents who had lived in the community 15 years or more were willing to pay much less than those who had lived in the Carter community from one to 15 years. This finding could be due to the higher income status of new residents in the community relative to that of older residents. In fact, most newer residents lived in the recently built subdivisions representing higher property values than the older residents' rural properties. In addition, the newer homes were typically owned by the residents in the AGE2, AGE3 and AGE4 categories who were also willing to pay more than the older residents to avoid a landfill.

As might be expected, respondents who were very concerned about the possible risks from the landfill were willing to pay \$262 annually, while those who perceived no risk gave zero WTP bids. Those households who were in close proximity to the landfill were willing to pay an average of \$200 more than those located further away.

#### Willingness to Pay Estimates

The willingness to pay (WTP) estimates for the Carter community to avoid a landfill are shown in Table IV-3. The estimate of average WTP per household was \$227 annually with a 95 percent confidence interval of

Table IV-3. Average, Total and Present Value Estimates of Willingness to Pay to avoid a Landfill in the Carter Community

|                                   | Value<br>(dollars) | 95 Percent Confidence Interval |
|-----------------------------------|--------------------|--------------------------------|
| Average annual household WTP      | 22.58              | 164.58 to 288.58               |
| Total annual WTP                  | 181,264.00         | 131,664 to 230,864             |
| Present value of total annual WTP | 2,167,871.75       | 1,574,668 to 2,761,075         |

\$165 to \$289. Total WTP of \$181,264 for the entire Carter population is estimated by multiplying the estimate of average annual household WTP by the 800 households in the community at the time of the survey. The 95 percent confidence interval for total annual willingness to pay is \$131,644 to \$230,864.

Also shown in Table IV-3 is the total cost of \$2,167,872 for locating a landfill in the Carter community. The present value of avoiding a landfill in the Carter community was estimated by equation IV-1:

$$P = \int_0^{50} \$181,264 \cdot e^{-.07875(t)} dt \quad (IV-1)$$

where:

7.875 = rate of discount

50 years = planning horizon

A planning horizon of 50 years and discount rate of 7.875 were selected to conform with federal procedures currently used in estimating benefits and costs of public projects (U. S. Water Resources Council, 1983; Hanson, U. S. Corps of Engineers, 1988).

#### Willingness to Pay Function

Ordinary least squares were used to estimate the relationship between WTP and the hypothesized explanatory variables as listed in Table IV-2. The results are presented in Table IV-4. All of the explanatory variables were 0,1 dummy variables, and the regression coefficients represent deviation from the deleted category. For example, the number in household (NIH) variable included four 0,1

Table IV-4. Ordinary Least-Square Estimates of Willingness to Pay to Avoid a Landfill in the Carter Community

| Explanatory Variable   | Regression Coefficient | t-ratio<br>114 d.f. | Level of<br>Significance |
|------------------------|------------------------|---------------------|--------------------------|
| NIH1                   | 148.73                 | 1.59                |                          |
| NIH2                   | 193.19                 | 2.05                | .05                      |
| NIH3                   | 29.21                  | .27                 |                          |
| AGE1                   | -71.59                 | -1.33               |                          |
| AGE2                   | -143.12                | -2.82               | .01                      |
| AGE3                   | 4.61                   | .08                 |                          |
| AGE4                   | 87.14                  | 1.76                | .10                      |
| SEX                    | 16.54                  | .47                 |                          |
| INC1                   | -1,126.30              | -6.06               | .01                      |
| INC2                   | -1,059.50              | -5.74               | .01                      |
| INC3                   | -1,001.50              | -5.55               | .01                      |
| INC4                   | -5.09                  | -.01                |                          |
| EDU1                   | -796.03                | -4.90               | .01                      |
| EDU2                   | -733.39                | -4.63               | .01                      |
| EDU3                   | -817.27                | -5.43               | .01                      |
| EDU4                   | -432.80                | -2.91               | .01                      |
| HOM                    | -97.74                 | -1.32               |                          |
| YIC1                   | -38.45                 | -.51                |                          |
| YIC2                   | 156.92                 | 3.47                | .01                      |
| YIC3                   | -18.46                 | -.52                |                          |
| DWS                    | -27.88                 | -.73                |                          |
| MFL1                   | 43.17                  | .81                 |                          |
| MFL2                   | -143.72                | -2.31               | .01                      |
| MFL3                   | -68.88                 | -1.79               | .10                      |
| POR                    | -226.16                | -5.61               | .01                      |
| Intercept              | 1,911.20               | 12.27               | .01                      |
| $\bar{R}^2$            | .8751                  |                     |                          |
| F-value                | 39.96                  |                     |                          |
| Number of observations | 140                    |                     |                          |

dummies: NIH1 (one to two), NIH2 (three to four), NIH3 (five to six) and NIH4 (more than six). Dummy variables are especially appropriate when using a model with qualitative data such as sex or race. Many of the hypothesized explanatory variables in the Carter landfill case are cardinal variables; however, one may use groupings or categories of a cardinal variable to define a qualitative variable (Johnston, 1984). The categories of the cardinal variable represent separate 0,1 dummies. To avoid having perfect multicollinearity, one of the categories for each explanatory variable was deleted from the regression equation.

Each category of an explanatory variable has a t-statistic to test the significance of the regression coefficient. A joint F-statistic is used to test the significance of all categories for an explanatory variable. The regression coefficients for the categories of an explanatory variable must be interpreted differently from a regression coefficient of a continuous variable. For instance, if NIH4 were the deleted category, the regression coefficient for NIH2 would measure the difference between average WTP for a three- to four-person household (NIH2) and the average WTP for a household with more than six persons (NIH4), holding all other characteristics constant between the two households. Testing the significance of NIH2 is, in effect, testing the hypothesis that average WTP for NIH2 minus average WTP for NIH4 is equal to zero (all other things constant). The joint F-statistic is used to test whether all categories of the NIH variable taken together significantly affect household WTP differently from the deleted category.

The interpretation of the regression coefficients can be most effectively demonstrated by using an example. Suppose a respondent fell into the following categories: NIH1, AGE1, a male, INC1, EDU1, a renter, YIC1, used district water, MFL1, perceived no risk. Then the estimate of his willingness to pay would be the intercept plus the corresponding regression coefficients, i.e.,

$$\begin{aligned} \text{WTP} = & 1,911.20 + 148.73 - 71.59 + 16.54 - 1,126.30 - 796.03 \\ & - 97.74 - 38.45 - 27.88 + 43.18 - 226.16 = \$264.52. \end{aligned}$$

Furthermore, if the respondent fell into the deleted categories for all other variables, the expected WTP value would be \$1,911.20 (the intercept). On the other hand, if the individual fell into the NIH1 category and the deleted category for all other variables, WTP would be \$2,059.93 (the intercept plus the coefficient for NIH1).

These regression coefficients enable one to predict the average willingness to pay for an individual given his/her inclusion in a particular category for each variable. The interpretation of the explanatory variable coefficients cannot be compared with the interpretation of the overall means in Table IV-2. The mean WTP for each category of a variable is an estimate of the WTP for the members in that particular category without regard to which categories they fall into for other variables. In contrast, the regression coefficients represent changes in WTP between individuals in different categories of the same variable, given that both are in the same category for every other variable.

The specific interpretation of the regression coefficients and their reliability as predictors of WTP is detailed below. It should be

noted that the *ceteris paribus* assumption applies to the interpretation of all regression coefficients, but to avoid redundancy it is not explicitly stated below.

#### Number in Household (NIH)

The joint F-statistic for NIH is 5.03 (Table IV-5). Thus, it can be concluded that the number of people in the household explains a portion of a household's WTP to avoid a landfill. The results of the survey indicate that those households in the Carter community with three to four members would be willing to pay \$193.19 more than those households with more than six members. This is the expected result given that per capita income decreases as household size increases, holding household income constant. An unexpected finding was that households with three to four family members (NIH2) were willing to pay more than households with one to two members (NIH1). This finding might be due to the near proximity of the local high school and recreation area to the proposed landfill site. In fact, during the interviews, many residents with children expressed this concern as their primary reason for opposing the BFI proposed site. It may be that households with children were willing to pay more to avoid the landfill because of this concern for their children.

#### Age (AGE)

The age variable was divided into five categories with the deleted category being those respondents over 65 years of age. AGE1 and AGE2 had negative signs, while AGE4 had a positive sign. Thus, one could conclude that respondents from age 36 to 45 were willing to pay the

Table IV-5. Joint F-Tests for Explanatory  
Variable Groups in the Willingness  
to Pay

| <u>Variable Name</u> | <u>F-Test</u> |
|----------------------|---------------|
| NIH                  | 5.03**        |
| AGE                  | 6.10**        |
| EDU                  | 10.78**       |
| INC                  | 7.20**        |
| YIC                  | 5.41**        |
| MFL                  | 3.44*         |

\*Significant at the .05 level.

\*\*Significant at the .01 level.

least to avoid a landfill, while the age 56-65 group was willing to pay more than any other age group. The joint F-statistic for AGE as shown on Table IV-5 suggests that the respondents' age is significant in explaining household willingness to pay. The pattern among the coefficients of the age variable was also unexpected. Heads of household who were 45 years and under were willing to pay considerably less than those heads of household who were over 65 years of age. Also, surprising was that the coefficient for AGE4 was considerably larger than the coefficients for the other categories. Again, this may be due to the fact that these families typically had high school age children who were perceived to be at risk from the landfill.

#### Income (INC)

All of the coefficients for income were negative and significant at the .01 level. Since the deleted dummy variable was INC5 (\$50,000 and over), the other coefficients indicate that as income increases, especially from \$30,000 to \$50,000, WTP also increases. It should also be noted that there was no appreciable difference among respondents with household incomes between zero and \$30,000. These households were willing to pay over \$1,000 less than households with incomes over \$30,000 per year. The joint F-statistic of 7.2 for INC indicates that income is highly significant in explaining household willingness to pay.

#### Education (EDU)

The joint F-value of 10.8 for education is significant at the .01 level, suggesting that the level of education strongly influences a respondent's WTP. All of the education variables had negative signs in

relation to the deleted dummy variable of EDU4 (some graduate education). Although the regression coefficients indicate that college graduates pay relatively more than noncollege graduates, there was no difference in WTP values among respondents with less than a college degree.

#### Homeownership (HOM)

The regression coefficient for HOM was -97.74. A negative sign would indicate that homeowners are willing to pay more than tenants to avoid having a landfill in the Carter community. However, the coefficient is not significantly different from zero. The regression results appear contradictory to the mean WTP estimates for HOM presented in Table IV-2. The mean WTP estimate for homeowners was \$241 annually, while tenants were only willing to pay \$20 per year. Again, it must be emphasized that in estimating the regression coefficients for each variable, all other variables were held constant. In deriving the mean WTP estimates, all other variables were allowed to vary. In other words, the regression coefficients for HOM were not influenced by the respondents' income, education, age, etc. However, the WTP mean estimates for HOM may have been influenced by the respondents' income, education, age and other variables.

#### Years in Community (YIC)

The only dummy variable representing years of residence in the Carter community which was significant was YIC2 (one to five years). Its positive coefficient means that households which have resided in the community from one to five years would be willing to pay \$156.92 more

per year than those residents who had lived in the community for more than 15 years (the deleted dummy variable). Again, this may be attributed to the fact that newer residents were typically families with school age children and heads of households between the ages of 45 and 60.

#### Drinking Water Source (DWS)

The regression coefficient for DWS was negative as expected. A negative sign indicates that households using district water would be willing to pay less than those households dependent on well or spring water for drinking supplies. However, this regression coefficient is not statistically significant at the .10 level so one cannot conclude that DWS explains household willingness to pay in the Carter community. Again, the regression results appear contradictory to the mean WTP estimates for DWS presented in Table IV-2, where residents dependent on well water were willing to pay a great deal more than those using district water. The difference in the regression and mean WTP estimates can be attributed to the influence of other explanatory variables on the mean estimates.

#### Miles from landfill (MFL)

The range for household distance from the proposed landfill was between zero and four miles. Two of the dummy variables (MFL2 and MFL3) were significant and had negative coefficients, indicating that households within a two- to three-mile radius of the proposed landfill were willing to pay less than those located three to four miles away. Even though MFL1 had a positive coefficient, its t-value indicates that

a household located within one mile of the landfill would not be willing to pay significantly more than those residing between three and four miles from the proposed site. This appears contradictory to the large WTP mean value for MFL1, but as stated earlier, the mean WTP value may have been influenced by income, education or other explanatory variables. The regression results which indicated that households in the three- to four-mile radius from the proposed site were willing to pay more than the adjacent residents can possibly be explained by the fact that the newer subdivisions were located in the three- to four-mile range. Again, these residents were very concerned about their children's exposure to risks from the landfill. This factor may have outweighed the risk concerns of residents closer in proximity to the proposed landfill site.

#### Perception of Risk (POR)

Respondents were asked to rate their perceptions of risk or level of concern over the proposed landfill on a scale of one to five with one representing the greatest concern. Eighty-five percent of the respondents chose "one," the highest level of concern and were willing to pay \$226.16 more than those who perceived no risk (number 5) from the landfill. The t-statistic of -5.619 in Table IV-4 shows that perceived risk is a highly significant explanatory variable for WTP. The mean WTP of \$262 for those who perceived a high risk from the landfill was also considerably different from those who perceived no risk (mean WTP of zero).

### Cost of Providing Piped Water

The estimated cost of having to hook up and pay for district piped water to the Carter residents who are currently on well or spring water is \$57,250 per year (see Table IV-6). This figure represents capital and yearly operating costs for 50 years. The capital costs of hookup are \$114,500 spread out over 50 years or \$2,400 annually. This figure was derived by multiplying the estimate of 229 Carter residents who presently have no access to district water by the estimated hook-up cost of \$500 (KUB Engineering Department, 1988). The estimated annual use charge is \$54,960 per year, which was derived by multiplying the 229 residents by the typical annual water bill in the Carter community of \$240 (KUB Engineering Department, 1988). The annual difference between WTP and the cost of piped water is \$124,014. The cost of piped water must be considered a lower bound estimate of the external costs from siting a landfill in the Carter community as it only includes the external effects on drinking water supplies. The estimated difference between total WTP and the cost of piped water represents other external costs not associated with possible drinking water contamination.

Table IV-6. Estimated Cost to Carter Residents of Switching from Well Water to District Piped Water

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|                                                                                                    |                                    |
|----------------------------------------------------------------------------------------------------|------------------------------------|
| Number of Carter community households using well water <sup>a</sup>                                | 229                                |
| Capital costs of hooking up to district water lines <sup>b</sup> (amortized over 50 years)         | $114,500 \div 50 = 2,290$ annually |
| Estimated annual water bill for Carter community residents presently using well water <sup>c</sup> | <u>54,960 annually</u>             |
| Total estimated annual costs                                                                       | \$57,250                           |

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<sup>a</sup>Estimated from sample statistic that 28.57 percent of the 800 households used well water as a drinking source.

<sup>b</sup>Data supplied by KUB Engineering Department and Tansley Plumbing of Chattanooga, Tennessee.

<sup>c</sup>Based on \$20 average monthly water bill for 229 households.

## CHAPTER V

### CONCLUSIONS

#### Summary of Study Results

The contingent valuation method was used in this study to generate an estimate of the annual external cost to the Carter community of having a landfill located in the area. The model yielded an average household WTP of \$227 per year with a total annual WTP of \$181,264 per year. This translates into an estimated present value for the Carter community of avoiding the proposed landfill equal to \$2,167,872.

The most statistically significant predictors of WTP were education, income, age, perception of risk, years in community and miles from the proposed landfill site. Homeownership, sex and drinking water source variables were insignificant. It is also worth noting the \$124,014 difference between the cost of switching well water users to district water and the total annual WTP. This would indicate the presence of external costs in addition to risks of groundwater contamination from the landfill.

#### Bias Issues

The three types of biases associated with contingent valuation studies were mitigated as much as possible. Starting point bias was avoided by asking open-ended WTP questions while giving the respondent a payment card which ranged in value from zero to \$4,080 (see Appendix 5).

To avoid upward strategic bidding on the part of respondents, they were asked to give their WTP to avoid a landfill rather than willingness to accept compensation for allowing a landfill to be sited in the area. The implication of the WTP approach is that the value derived from the survey should be considered a conservative estimate. The large number of zero bids also implies that the WTP value may be understated. In a further attempt to minimize strategic bias, two pretests were performed to discover how best to present the hypothetical market so that respondents would have less incentive toward strategic bidding.

One way to test vehicle bias would be to ascertain whether respondents would report different amounts depending on the mode of payment such as taxes, user fees or simply higher prices. In the Carter survey, the Arrow and Randall approach was followed where the most realistic mode of payment was offered in the contingent market (Brookshire, et al., 1981). Respondents were told that their hypothetical WTP values would be made in the form of higher prices for garbage service.

Finally, the two pretests of the questionnaire also helped to reduce the possibility of informational bias. In the first pretest survey, the respondents were given the questionnaire and asked to mail the completed form back to the researcher in a preaddressed, postage paid University of Tennessee envelope. It was concluded that this type of survey was ineffective. Not only was the response rate low, but it was clear that respondents did not understand the questions in the survey. Therefore, another pretest was performed where the researcher personally interviewed each respondent. This pretest resulted in much

more reliable information with only one refusal to cooperate with the survey.

### Policy Implications of Study

The results of this study may be considered by policymakers for a number of reasons. First, it would be useful for decision makers to know the full costs of landfills when considering alternative measures for disposing of municipal waste. In Knox County, this issue is very much at the forefront with significant local opposition to both the siting of a new landfill and a mass refuse incinerator. The external costs of siting these facilities should be considered.

Regardless of the policies made while developing a comprehensive waste management plan, there is no doubt that a new landfill must be sited in Knox County. Even with a massive recycling program, there will be wastes for which land disposal is necessary. Alternatively, incineration also leaves about 20-40 percent of the wastes to be landfilled (Weston, 1986). The question of where to locate new landfills is one which must be resolved. From the Carter landfill case, a great deal can be learned. Not only may the producers of garbage have to compensate those who allow a landfill to be sited "in their backyard," but county officials may have to take a more active role in the landfill siting process. This may entail stricter landfill regulations, more research on geologically suited sites and a commitment to public awareness and environmental sensitivity.

This study may also imply that the general public is very much aware of the risks associated with landfills. Eighty-five percent of

the surveyed population reported the maximum concern for health and environmental risks on a scale from one to five. To express the sincerity of this concern, those same respondents were willing to pay to reduce these risks.

Another implication of this study is to point out the power in community cohesion. While it may not be evident from the statistical results, the typical Carter community resident's WTP reflected concern not only for his/her household, but also the community as a whole. From the personal interviews, the researcher ascertained a strong sense of community pride and concern for the environment. This cohesion is further evidenced by the fact that 600 persons participated in the first public community meeting held to respond to the proposed Carter landfill. The residents also initiated a community based recycling program to pay the attorney's fees in their opposition to the landfill.

A final implication of the study is in the assessment of the contingent valuation method of valuing the social costs of landfills. Even though this was a single case study, one may infer from the results that respondents were able to understand the contingent market posed to them. Two pretest surveys in this study showed that personal interview questionnaires were much more effective in eliciting accurate data than mail approaches. Respondents also benefited greatly by the use of payment cards with other typical fees paid for public services. Also, the fact that there was a significant difference between the total external cost of locating a landfill in the Carter community and the

cost of piped water indicates that nonuse values should be considered in valuing alternative waste management strategies.

#### Limitations of Study and Suggestions for Future Research

This study was limited in several ways. First, the study cannot provide conclusive analysis on contingent valuation as a method for valuing the external costs of landfills. The fact that the Carter community was under an actual threat of having a landfill sited in the area may have artificially influenced their WTP values. To test the validity of the Carter contingent valuation study, two additional surveys could be administered to areas similar in socioeconomic characteristics to those of the Carter community. To test the effect of the threat of a landfill on WTP, a rural community with no threat of a landfill should be surveyed, as well as a community which has actually experienced the siting of a landfill in their area.

Secondly, for a complete analysis of waste management alternatives in Tennessee, the total costs of landfill disposal, incineration and recycling should be evaluated. A contingent valuation study, similar in design to the Carter case, could be administered to a community to determine their willingness to pay to avoid a mass burn incinerator. The external costs of recycling, which include the time and space for collecting and marketing recycled products, also needs to be considered.

Thirdly, considering the social costs of landfills, the need to consider recycling as a viable option in developing a state or local waste management plan is essential. In a national study conducted by the Institute for Local Self-Reliance (Selman and Perkins, 1988), it was

concluded that on the national average, recycling is the most economical alternative for disposing of garbage on a per ton basis. Depending on the characteristics and needs of a community, issues such as curbside versus buy back collection programs, mandatory versus voluntary participation, education, composting and financing must be investigated, and external costs need to be evaluated.

Up to \$20 billion will be invested in new disposal facilities in the next five years (Selman and Perkins, 1988). Therefore, a complete analysis is needed which compares the total costs of all existing solid waste processing technologies.

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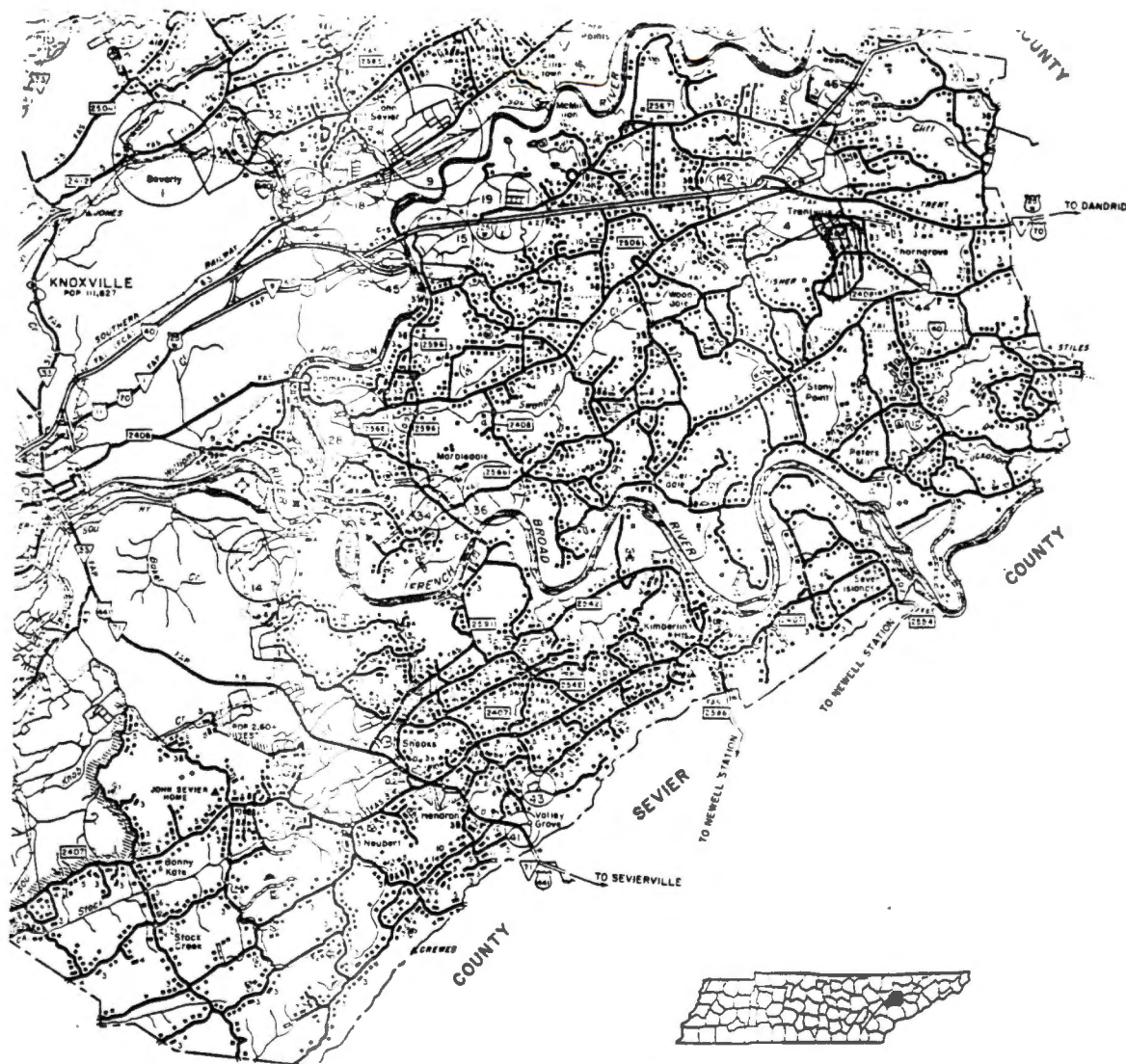
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## APPENDICES

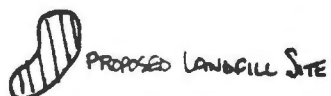
**Appendix 1. Map of Carter Community and Proposed Landfill Site**



BLOUNT

# GENERAL HIGHWAY MAP KNOX COUNTY TENNESSEE

PREPARED BY THE  
TENNESSEE DEPARTMENT OF HIGHWAYS  
RESEARCH AND PLANNING DIVISION  
IN COOPERATION WITH THE  
U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL HIGHWAY ADMINISTRATION



**Appendix 2. Analysis of Available Landfill Capacity for  
Knox County, Tennessee**

**ANALYSIS OF  
AVAILABLE LANDFILL CAPACITY  
FOR  
KNOX COUNTY, TENNESSEE**

**PREPARED FOR  
  
BROWNING-FERRIS INDUSTRIES**

**BY  
  
BARGE, WAGGONER, SUMNER AND CANNON  
SUITE 2400 PLAZA TOWER  
KNOXVILLE, TENNESSEE 37929**

**FEBRUARY 1987**

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## 1.0 INTRODUCTION

### 1.1 Purpose

The purpose of this report is to analyze the capacity and life of the permitted landfill space available to Knox County. Of particular interest is the investigation of the need for additional landfill capacity once existing permitted capacity has been depleted. As Knox County proposes to construct a solid waste incinerator, this report shall also consider the impact of such a project on the needed landfill capacity.

### 1.2 Overview

Knox County is now being serviced by two existing landfills. One is located on Rutledge Pike (Twin Oaks) and is operated by Browning-Ferris Industries. The other is located along I-75 (Chestnut Ridge) and is operated by Waste Management, Inc.

A study of the available landfill capacity in Knox County is presented which considers the solid waste generation rates and their probable change as a result of the projected start up of a mass burning refuse incinerator.

The findings are that the current landfill capacity at the Twin Oaks landfill will be depleted by December 1988. If a scenario develops in which Chestnut Ridge is the only permitted landfill in operation after that time, then it will reach capacity in February 1990.

With full scale start-up of the incinerator not likely until at least 1992, there will be a need to landfill over 1.5 million cubic yards of solid waste per year for which landfill capacity is not presently available. When the incinerator is finally brought on line there will still be a need to dispose of over 350,000 cubic yards per year.

## 2.0 METHODOLOGY AND ASSUMPTIONS

In order to project the solid waste production rate of Knox County and to estimate the life of the existing landfills several assumptions were made. These are described below.

Population - Figures from the Center for Business and Economic Research, University of Tennessee, November 1986 were used.

Refuse Generation - Two landfills serve Knox County: Twin Oaks in Knox County and Chestnut Ridge in Anderson County.

Twin Oaks Landfill - Refuse volume is based on gate receipts and is recorded in cubic yards. Current waste volume averages 70,000 cubic yards per month.

Chestnut Ridge Landfill - The amount of refuse received is based upon the calculated volume generated by the Knox County population projections plus the volumes trucked from the other counties. The total volume at Chestnut Ridge is reported at 800 tons per day; it is assumed that 600 tons per day is generated in Knox County.

Landfill Compaction Factor - The net compaction factor of 2.1 is used in the capacity calculations for both landfills. This is the factor measured at Twin Oaks and is typical of well operated landfills. The factor represents that for every 2.1 cubic yards of garbage received at the landfill, that volume will be reduced by compaction to 1.0 cubic yard of landfill space. The factor also accounts for daily cover volume.

The in-truck density of the solid waste as it arrives at the gate is assumed to average 500 pounds per cubic yard.

Landfill Life - Assumes that existing permitted sites will be operated and closed according to state approved operation plans and that no expansions are approved. Calculations are based on 1986 refuse generation rates and have been projected based on anticipated population growth.

Incineration Schedule - Based on projected schedule as estimated by Bill Hazel, HDR Techserve Incorporated, Knox County Incinerator Consultant, December 29, 1986.

Down Time - Non-combustible allowance and incinerator downtime for schedule and unscheduled maintenance of 15% by volume is assumed based on December 29, 1986 telephone conversation with Bill Hazel, HDR.

Incinerator Residue - Likewise the non-combustible residue of 10% by volume is based on an industry accepted average confirmed by Bill Hazel. However, a more refined number will be determined as the incinerator preliminary design is completed.

### 3.0 PROJECTION OF SOLID WASTE DISPOSAL NEEDS

#### 3.1 Population Trends and Projections

##### 3.1.1 Historical Perspective - Population

Population may be examined with respect to two primary parameters: rates of growth and absolute increases or decreases in an area's population. Although Knox County ranks third in statewide population, it has been leading the ratio of growth for the four metropolitan counties since 1960. Table 1 indicates the total population of these counties since 1960 and Table 2 provides insight into the average rates of growth since 1960.

**TABLE 1****Population of Major Metropolitan Counties in Tennessee  
1960-1985**

|                 | <u>1960</u> <sup>1</sup> | <u>1970</u> <sup>1</sup> | <u>1980</u> <sup>1</sup> | <u>1985</u> <sup>2</sup> |
|-----------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Knox County     | 250,523                  | 276,293                  | 319,694                  | 332,200                  |
| Davidson County | 399,743                  | 447,877                  | 477,811                  | 491,300                  |
| Shelby County   | 627,019                  | 722,111                  | 777,113                  | 799,700                  |
| Hamilton County | 237,905                  | 255,077                  | 287,740                  | 284,500                  |

Sources: <sup>1</sup> Tennessee Statistical Abstract 1985/86  
Center for Business and Economic Research  
University of Tennessee

<sup>2</sup> Center for Business and Economic Research  
University of Tennessee (Census Estimate)

**TABLE 2****Rate of Growth, 1960-1985 \***  
**Major Metropolitan Counties**  
**State of Tennessee**

|                 | 1960-1985           |       | 1970-1985           |       | 1980-1985           |       |
|-----------------|---------------------|-------|---------------------|-------|---------------------|-------|
|                 | Avg. Rate of Growth |       | Avg. Rate of Growth |       | Avg. Rate of Growth |       |
|                 | 25 yr.              | 1 yr. | 15 yr.              | 1 yr. | 5 yr.               | 1 yr. |
| Knox County     | 32.6%               | 1.3%  | 20.2%               | 1.3%  | 3.9%                | 0.8%  |
| Davidson County | 22.9%               | 0.9%  | 9.7%                | 0.6%  | 2.8%                | 0.6%  |
| Shelby County   | 27.5%               | 1.1%  | 10.7%               | 0.7%  | 2.9%                | 0.6%  |
| Hamilton County | 19.6%               | 0.8%  | 11.5%               | 0.8%  | -1.1%               | -0.2% |

Although not representative of the growth in the Metropolitan Statistical Areas (MSA)\*\* associated with the above referenced counties, Table 2 does indicate that Knox County has experienced

\* Calculated based on data provided by the Center for Business and Economic Research, University of Tennessee, Nov., 1986.

\*\* Metropolitan Statistical Areas comprise counties that meet certain parameters associated with population density and economic dependence.

a strong rate of growth since 1960 compared to the other urban core counties. Analysis of the four Metropolitan Statistical Areas indicates that the Knoxville MSA, of which Knox County is the central county, experienced a rate of growth since 1960 second only to Nashville.

Considering the population growth trends evident for Knox County and the MSA, it is assumed that the County population will continue to experience strong gains in the future even without consideration of potential growth inducements such as the Technology Corridor or additional industrial development.

### 3.1.2 Projections - Population

Population projections can be highly variable depending on the sources, assumptions, and periods encompassed. The most recent projections for Knox County only go through the year 2000 indicating a population of 343,648 in 1990 and 363,540 in the year 2000.\* The most recent projections available from the Knoxville/Knox County Metropolitan Planning Commission varied minimally with projections of 345,881 in 1990 and 367,954 in the year 2000\*\*. Averaging these projections results in projections for 1990 of 344,740 and 365,747 for the year 2000.

\* Tennessee State Planning Office, Department of Economic and Community Development, July 3, 1986.

\*\* Knoxville/Knox County Metropolitan Planning Commission, November 29, 1983.

### 3.2 Solid Waste Generation

#### 3.2.1 Population and Waste Generation Relationship

The amount of solid waste generated in Knox County is a function of the number of people, the per capita generation and industrial and commercial contribution. The volume of solid waste generated in Knox County is estimated at over 1,500,000 cubic yards per year. The 1985 population of 332,200 shows a per capita generation rate of 6.3 pounds per person per day. This figure accounts for residential, commercial, and industrial solid wastes. This rate of generation is assumed to be constant through the year 2000.

#### 3.2.2 Projections - Required Landfill Capacity

##### Current Waste Generation in Knox County

Assume: 1) All waste received at Twin Oaks is from Knox County

2) 75% of the solid waste disposed of at Chestnut Ridge originates in Knox County

Data: 1) Twin Oaks receives 70,000 gate cu. yd. per mo. (before landfill compaction) on an average of 5.5 days per wk.

2) Chestnut Ridge receives a total of 800 tons per day with 600 tons per day coming from Knox County on an average of 5.5 days per wk.

Total Waste Generated:

$$2,940 + 2,400 = 5,340 \text{ gate cu. yd. per day}$$

$$5,340 \times 5.5 \times 52 = 1,527,200 \text{ gate cu. yd. per yr.}$$

##### Amount of Waste Generated Per Capita in Knox County

$$\frac{1,527,200 \text{ cu. yd.}}{\text{yr.}} \times \frac{500 \text{ lb.}}{\text{cu. yd.}} \times \frac{\text{yr.}}{365 \text{ day}} = \frac{2,092,100 \text{ lb.}}{\text{day}}$$

$$\frac{\frac{2,092,100 \text{ lb.}}{\text{day}}}{332,200 \text{ (pop.)}} = 6.3 \text{ lb. per day}$$

### Required Landfill Capacity

The 1990 forecast population figures for Knox County yield a daily generation of 1,086 tons. Projecting the year 2,000 population corresponds to a daily generation of 1,152 tons. At an average in-truck density of 500 pounds per cubic yard and a landfill compaction factor of 2.1, the required landfill capacities are projected as follows:

|           |                        |
|-----------|------------------------|
| Year 1990 | 755,100 cubic yards/yr |
| Year 2000 | 800,900 cubic yards/yr |

### **3.3 Capacity and Remaining Life of Existing Landfills**

#### **3.3.1 Twin Oaks**

The following assumptions and data were used to project the remaining life of the existing Twin Oaks landfill. By these calculations, the landfill will reach capacity approximately in December, 1988. Capacity has been determined by Browning-Ferris Industries using ground and aerial surveying methods and with comparison to state approved design documents.

#### Twin Oaks Capacity

Assume: 1) 70,000 gate cu. yd. per mo.

2) 2.1 net compaction factor

Data: 1) Gross remaining air space 3/8/86 = 1,405,860 cu. yd.

2) Total volume of final cover and perimeter berms -  
296,100 cu. yd.

Remaining Life:

$\frac{70,000}{2.1} \times 12 = 400,000 \text{ compacted cu. yd. yr.}$

$(1,405,860 - 296,100) / 400,000 = 2.77 \text{ yr.}$

From March 1986 + 2.77 yr. = Dec. 1988

### 3.3.2 Chestnut Ridge

The information below was used to calculate the remaining life of the existing Chestnut Ridge Landfill. These calculations indicate that the landfill will reach capacity in February 1991. Capacity was calculated by Barge, Waggoner, Sumner and Cannon using ground and aerial surveying techniques and by comparison to State permit documents.

#### Chestnut Ridge Capacity

Assume: 1) 800 tons/day at 5-1/2 days/wk.  
(600 tons/day from Knox Co., 200 tons/day from other counties)

2) 2.1 net compaction factor

3) truck density = 500 lb./cu. yd.

Data: \*1) Net remaining air space 12/4/86 = 1,939,740 cu. yd.

2) Total volume of final cover 104,390 cu. yd.

Remaining Life:

$$\frac{800 \text{ tons}}{\text{day}} \times \frac{5.5 \text{ days}}{\text{wk.}} \times \frac{52 \text{ wk.}}{\text{yr.}} \times \frac{2,000 \text{ lb.}}{\text{ton}} \times \frac{\text{cu. yd.}}{500 \text{ lb.}} \times \frac{1}{2.1} = 435,800$$

$$(1,939,740 - 104,390) / 435,800 = 4.2 \text{ yrs.}$$

### 3.3.3 Remaining Life of Combined Landfills

For purposes of this analysis, a scenario has been developed which predicts that when the Twin Oaks Landfill reaches capacity and closes, then all solid waste now going to Twin Oaks will be diverted to Chestnut Ridge. This is a valid assumption under the premise and basis of this report. That is that the two existing landfills are all that will be available to Knox County unless another landfill is developed. Under this scenario, Chestnut Ridge

\* As determined from Aerial Topographic Mapping

obviously will reach capacity more rapidly and will have to close much earlier than originally projected. By the calculations below, the Chestnut Ridge Landfill will reach capacity and close in February 1990.

Scenario for Determining Life of Both Landfills

- 1) It is assumed that when Twin Oaks reaches capacity and shuts down, the 400,000 compacted cubic yards per year being received would be diverted to Chestnut Ridge.
- 2) The total solid waste being received at Chestnut Ridge would be 835,474 compacted cubic yards per year.
- 3) The remaining air space at Chestnut Ridge in Dec. 1988 (when Twin Oaks closes) is based upon the following:
  - a) Dec. 1986 to Dec. 1988 = 2.0 yrs.
  - b)  $435,474 \text{ compacted cu. yd. per yr.} \times 2.0 \text{ yrs.} = 870,948 \text{ compacted cu. yd. to be placed}$
  - c) Percentage of air space used is 45%  $(870,948/1,939,740)$
  - d) Assume 45% cover material to have been used = 46,977 cu. yd.
  - e) Remaining air space at Dec. 1988  
 $1,939,740 - 870,948 - 46,977 = 1,021,815 \text{ cu. yd.}$
  - f) Remaining air space at Dec. 1988 less remaining cover material is the amount available for solid waste disposal  
 $1,021,815 - 57,417 = 964,398 \text{ cu. yd.}$
- 4) Revised projected date for Chestnut Ridge to have reached capacity -  $964,398/835,474 = 1.2 \text{ yrs.}$   
 Dec. 1988 + 1.2 yrs. = Feb. 1990

### 3.4 Proposed Incinerator

The construction of an incinerator to serve all of Knoxville and Knox County would reduce required landfill capacity. It is generally accepted within the solid waste management industry that a minimum of five years is needed for planning, design, environmental assessment, permitting, contract development, construction and shakedown. If the incinerator project were to begin now, the earliest the incinerator can be expected to be operational is early 1992.

With closure of both landfills in 1990, a two year period will occur with a generation of over 1,500,000 cubic yards of garbage each year while no disposal capacity will remain. Once an incinerator is on-line, over 350,000 cubic yards per year of ash, non-combustibles, and by-pass material must be landfilled.

When this amount of waste and refuse is compacted and disposed of at a future landfill site, that site will be filled at a rate of approximately 1/2 of that at which either of the two existing landfills is presently being filled. This scenario is based upon a 1.5 compaction factor of the waste material.

**SUMMARY**

- The combined capacity of landfills serving Knox County will be depleted by February 1990.
- The earliest the incinerator can be expected is 1992, leaving at least two years between depletion of landfill space and operation of the incinerator.
- After depletion of existing permitted landfill capacity in February 1990, approximately 1.5 million cubic yards of garbage will continue to be generated in Knox County each year. Once the incinerator is operational, over 350,000 cubic yards of incinerator ash, non-combustibles, and bypass waste must be landfilled each year thereafter. This is a disposal rate approximately equivalent to one-half the volume currently disposed of at either existing landfill serving Knox County.

SUPPLEMENT NUMBER ONE

ANALYSIS OF  
AVAILABLE LANDFILL CAPACITY  
FOR  
KNOX COUNTY, TENNESSEE

PREPARED FOR  
  
BROWNING-FERRIS INDUSTRIES

BY  
  
BARGE, WAGGONER, SUMNER AND CANNON  
SUITE 2400 PLAZA TOWER  
KNOXVILLE, TENNESSEE 37929

APRIL 1987

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## 1.0 INTRODUCTION

In February 1987, Barge, Waggoner, Sumner and Cannon completed an investigation for Browning-Ferris Industries entitled "Analysis of Available Landfill Capacity for Knox County, Tennessee." This report is presented as a supplement to the original investigation. The analysis performed in February remains valid under the assumptions as stated at that time. The basic conclusion outlined in the Summary, that Knox County will need additional landfill capacity even after start-up of the proposed incinerator, remains unchanged.

One development, which has become known since the original report was prepared, however, does require further considerations and evaluations. Apparently Waste Management, Inc. has submitted an application to the Tennessee Division of Solid Waste for an approximate fourteen acre permit extension to its existing Chestnut Ridge Landfill.

For purposes of this report it is assumed that all permit conditions can be met and that the application for the Chestnut Ridge extension will be approved by the Tennessee Division of Solid Waste. The analysis presented herein evaluates the impact on the life of available landfill capacity for Knox County due to the proposed extension.

## 2.0 CHESTNUT RIDGE EXTENSION

Information obtained from the permit application for the Chestnut Ridge extension is used as the basis for the calculations and analysis presented later in this report. Unless noted otherwise below, the basic assumptions and methodologies as stated in the original report are applicable for this supplemental evaluation. The following paragraph is quoted from the application for the "Chestnut Ridge Sanitary Landfill Extension; December 22, 1986."

"Based on current records from the Chestnut Ridge Sanitary Landfill, the average daily disposal rate was determined to be 1,000 cubic yards of refuse (in-place) per day. It is estimated that the remaining service life of the landfill including the proposed extension is 9.6 years. This is based on an anticipated average of 1,200 cubic yards of refuse (in-place) per day due to projected growth of communities served by the landfill. Estimated total available refuse fill volume of the entire landfill is 3,563,000 cubic yards. Service life and soil balance calculations are provided in Attachment 1."

The calculations and assumptions outlined below are summarized from the extension permit application.

1. Total remaining airspace including the extension = 4,580,960 yd.<sup>3</sup>
2. Assume a 3.5:1 refuse to cover ratio (includes daily cover, intermediate cover and final cover)
3. Amount of cover =  $\frac{1}{4.5} \times 4,580,960 \text{ yd.}^3 = 1,017,990 \text{ yd.}^3$
4. Total remaining refuse volume =  
 $4,580,960 \text{ yd.}^3 - 1,017,990 \text{ yd.}^3 = 3,562,970 \text{ yd.}^3$
5. Assume a 2:1 compaction ratio (Note: a compaction ratio of 2.1:1 was used in the original report)
6. Gate yard volume =  $2 \times 3,562,970 = 7,125,940 \text{ gate yd.}^3$
7. Assume 2,400 gate yd./day, 6 days/wk., 52 wks./yr.
8. Life capacity =  
 $7,125,940 \text{ gate yd.}^3 \times \frac{1 \text{ day}}{2400 \text{ gate yd.}^3} \times \frac{1 \text{ wk.}}{6 \text{ days}} \times \frac{1 \text{ yr.}}{52 \text{ wks.}} = 9.5 \text{ yrs}$

### 3.0 CAPACITY AND REMAINING LIFE OF EXISTING LANDFILLS

#### 3.1 Twin Oaks

From the original report, it was calculated that the Twin Oaks landfill will reach capacity approximately 2.77 years from March, 1986. These calculations are still valid which means the Twin Oaks landfill will consume all its airspace capacity by approximately December, 1988.

### 3.2 Chestnut Ridge

Similar to the scenario developed in the original report, this supplement considers that when Twin Oaks reaches capacity and closes, all solid waste now going to Twin Oaks will be diverted to Chestnut Ridge. According to this scenario, Chestnut Ridge will reach capacity more quickly than the 9.5 years projected earlier.

#### Revised Chestnut Ridge Capacity

1. Gate cubic yards remaining when Twin Oaks reaches capacity in Dec. 1988 =  $\frac{7.5}{9.5} \times 7,125,940 \text{ yd.}^3 = 5,625,742 \text{ yd.}^3$
2. Annual Chestnut Ridge volume =  
 $\frac{2,400 \text{ gate yd.}^3}{\text{day}} \times \frac{6 \text{ day}}{\text{wk.}} \times \frac{52 \text{ wk.}}{\text{yr.}} = 748,800 \text{ yd.}^3/\text{yr.}$
3. Annual Twin Oaks volume =  
 $\frac{70,000 \text{ yd.}^3}{\text{month}} \times \frac{12 \text{ months}}{\text{yr.}} = 840,000 \text{ yd.}^3/\text{yr.}$
4. Total volume to be delivered to Chestnut Ridge after Dec. 1988 =  
 $748,800 \text{ yd.}^3 + 840,000 \text{ yd.}^3 = 1,588,800 \text{ yd.}^3/\text{yr.}$
5. Revised remaining life =  
 $5,625,742 \text{ yd.}^3 / 1,588,800 \text{ yd.}^3/\text{yr.} = 3.54 \text{ yr.}$   
 Dec. 1988 + 3.54 yr. = June 1992

#### 4.0 SUMMARY AND CONCLUSIONS

1. If Waste Management receives all necessary approvals for its requested expansion, Chestnut Ridge will reach capacity in mid-1996 at its current disposal rate.
2. If Twin Oaks closes in December 1988 and diverts its waste to Chestnut Ridge (assuming expansion), Chestnut Ridge will reach capacity in mid-1992.
3. If the incinerator comes on-line in 1992, essentially no landfill capacity will remain to handle ash, non-combustibles, and bypass material which must be landfilled.
4. Even with an incinerator, a future landfill will be needed which will be filled at a rate of approximately 1/2 of that at which either of the two existing landfills is presently being filled.

**Appendix 3. Report of Geologic Investigation**



STATE OF TENNESSEE  
DEPARTMENT OF HEALTH AND ENVIRONMENT  
1605 PROSSER ROAD  
KNOXVILLE, TENNESSEE 37914-3434

February 4, 1987

REPORT OF GEOLOGIC INVESTIGATION

Subject: Knox County, Browning Ferris Industries (BFI) - Geologic Evaluation of a site proposed for use as a sanitary landfill.

Dates: Different phases of this evaluation were conducted as follows:

November 12-20, 1986 - Exploratory augering and site reconnaissance.

December 3, 17 and 30, 1986 - Piezometer checks.

January 1987 - Evaluation of various spring and well data and reviews of auger results.

Auger drilling was performed by Soil and Material Engineers, Inc., under the supervision of Paul Niebergall, Staff Geotechnical Engineer, of that company. Mr. Steve Anderson, BFI, and Mr. Richard Martin, Environmental Management and Planning Engineers, were present at various times during the investigation.

Location and Property Description: Quadrangle 155-SW, Mascot. The proposed site is located in east Knox County on the southeast side of Carter Mill Road (see attached location map).

This site, which comprises approximately 180 acres, consists of portions of two adjoining tracts, the owners of which are shown as Amburn and Ambrister.

BFI has also optioned property to the northwest of Carter Mill Road which includes tracts of two other owners, Burnett and Hance, but this property is presently only being considered for access purposes and perhaps also as a future source of cover soil. The individual tracts are shown on the location map.

Previous Investigation: A preliminary geologic investigation of this site was conducted on October 31, 1986, by the Division of Solid Waste Management (DSWM), the results of which are presented in the Report of Geologic Investigation, November 7, 1986, by G. N. Pruitt. This report concluded that "This site appears to be potentially suitable for landfill use..." and the factors which supported this conclusion were (1) the

presence of deep residual soils, (2) moderate to low slopes over most of the site and (3) the absence of streams and springs over the site. Adverse features noted were sinks and depressions, and large drainage systems which drain off site areas through the site.

The aforesaid report has described the topography, geology, hydrology, etc., of this site and therefore only such descriptions as are necessary for clarity or further definition will be restated or expanded upon herein.

BFI had conducted a brief preliminary investigation of this site during September, 1986, prior to requesting an evaluation by DSWM. This investigation included twelve (12) exploratory soil borings, B-1 through B-12; and various soil tests were performed on selected samples taken by either split-spoon or Shelby tube methods. The soil testing included permeability determinations which are reported herein. This earlier investigation, including the soil testing, was performed by Soil and Material Engineers, Inc., in cooperation with Environmental Management and Planning Engineers.

Investigative Procedures and Results: This investigation has included both exploratory soil borings and more extensive visual inspections of the site. Auger holes were drilled at fourteen (14) locations, B-101 through B-114, designated by DSWM, in order to determine the general soil conditions over the site and to ascertain if groundwater occurs within the limits of the drill penetrations. Drill hole logs are attached.

Six holes were drilled without refusal to the depths indicated below:

- B-105, 58 feet
- B-106, 58 feet
- B-107, 48 feet
- B-109, 53 feet
- B-110, 58 feet
- B-111, 58 feet

The drill was equipped with sufficient auger sections for a maximum depth of 58 feet; however, holes B-107 and B-109 were terminated at shallower depths. Hole No. B-107 was located to check a depression that was suspected to have been a farm pond; and the drill was experiencing considerable difficulty at the B-109 location due to extremely hard, stiff clay throughout the progression of the hole.

The remaining eight holes were drilled to refusal, apparently on bedrock, at varying depths as indicated in the following:

- B-101, 25.5 feet
- B-102, 28 feet
- B-103, 26.5 feet
- B-104, 47.5 feet
- B-108, 48 feet
- B-112, 54.5 feet
- B-113, 37.5 feet
- B-114, 25 feet

Hole No. B-102 may have encountered a chert boulder, but this could not be determined.

The drilling has confirmed that a very thick mantle of residual clay covers most of this site, and the material encountered was predominantly reddish brown to brown, silty clay with generally sparse amounts of chert which was evident mostly as small weathered fragments. Some zones of more abundant chert were noted. All holes were "dry" upon completion, although four holes, B-101, B-104, B-113 and B-114, did exhibit very moist to near wet soils at the bottom of each. These four holes, which refused on bedrock, were drilled at relatively low elevations on the site.

The preliminary investigation by BFI has shown the soils here to have a generally low hydraulic conductivity (permeability). The soils of this site (not topsoil) appear to fall mostly into the MH to CH categories of the Unified Soil Classification System. These soils are relatively impervious with permeabilities indicated from  $1.93 \times 10^{-5}$  to  $5.37 \times 10^{-7}$  depending on location and depth. Although residual soils derived from the Knox dolomite are generally low permeability materials, they are not homogeneous, and they always contain anomalous zones of chert and sand or silt according to the original constituents of the parent rock and the structural attitude of that rock before the soil was formed.

The following table partially summarizes the soil test results reported from the aforesaid investigation:

SOIL TEST DATA

| Boring No. | Sample Depth, Ft. | Liquid Limit | Plasticity Index | Permeability cm/sec   |
|------------|-------------------|--------------|------------------|-----------------------|
| B1         | 15-17             | --           | --               | $1.93 \times 10^{-5}$ |
| B1         | 25-27             | 51           | 19               | $1.48 \times 10^{-6}$ |
| B1         | 35-37             | 58           | 22               | --                    |
| B8         | 35-37             | --           | --               | $3.1 \times 10^{-6}$  |
| B8         | 45-47             | 63           | 26               | $6.54 \times 10^{-7}$ |
| B9         | 15-17             | 68           | 30               | $1.62 \times 10^{-6}$ |
| B10        | 25-27             | --           | --               | $5.37 \times 10^{-7}$ |
| B10        | 35-37             | 44           | 19               | $5.6 \times 10^{-6}$  |

Piezometers were installed in four holes, B-101, B-103, B-104 and B-113, in order to observe any groundwater occurrence within the depths of these holes, three of which did appear to have considerable moisture near their termini. The piezometers have been observed periodically and checked with an electric water level indicator, and no water has been observed as of December 30, 1986. The piezometer checks were as follows:

| <u>Hole No.</u> | <u>Depth</u> | <u>Installed</u> | <u>Observations</u> |                 |                 |
|-----------------|--------------|------------------|---------------------|-----------------|-----------------|
|                 |              |                  | <u>12/03/86</u>     | <u>12/17/86</u> | <u>12/30/86</u> |
| B-101           | 25.5'        | 11/19/86         | Dry                 | Dry             | Dry             |
| B-103           | 26.5'        | 11/20/86         | Dry                 | Dry             | Dry             |
| B-104           | 47.5'        | 11/20/86         | Dry                 | Dry             | Dry             |
| B-113           | 37.5'        | 11/19/86         | Dry                 | Dry             | Dry             |

The very moist to wet conditions observed in holes B-101, B-104 and B-113 are interpreted to be the near-saturated zone which usually occurs at the soil-bedrock interface where descending water is interrupted and diverted more or less laterally until it "finds" suitable pathways or conduits to facilitate its downward flow to the "water table." In addition to the piezometers, several of the open auger holes have also been re-inspected and no water has been observed in any of them. The locations of springs, both known and reported, were plotted on a large scale topographic map of the area and hypothetical hydraulic gradients were projected into the subject site which indicate that the groundwater surface is considerably lower than the deepest penetrations of the drill holes. Even during times of normal rainfall cycles it is unlikely that the auger holes here would have penetrated groundwater.

The groundwater flow direction in the area of this site appears to be generally northward as indicated by the locations and elevations of area springs. However, in the immediate vicinities of springs and major drainage features groundwater flow may vary considerably according to the effect of local discharge or recharge features. This site does not appear to be within the recharge areas of either the Weaver Spring or the Carter Cave Spring.

Sinks and depressions are present at several localities over this site. Two of these features appear to be active and have sufficient relief to be excluded from any proposed landfill facility; however, several depressions are very shallow and are probably inactive relict features. Two depressions (see map) are suspected of having been farm ponds constructed with low earthen dikes blocking the drainages of shallow excavations. Remnants of the "dikes" are still visible, and the existence of these ponds has been confirmed by a long-time resident of the area. Drill holes B-101, B-107, B-109 and B-111 were placed in shallow depressions and except for B-101 (bedrock at 25.5') the holes were terminated with no refusal at depths of 48, 53, and 58 feet, respectively.

One sink with bedrock outcrops and a cave-like opening was found near the east end of the site, apparently just off the subject property (see map). Bedrock outcrops, indicating pinnacles and/or shallow soil conditions, were also observed in this area of the site. Sinks and depressions are indicated on attached maps.

Further inspections have revealed no streams or springs on this site. Although two "blue-line streams" are shown on the topographic quadrangle, these features have been observed during moderate to heavy rainfall conditions and no water was seen flowing therein, nor have any "wet

weather springs" been observed. It is probable, however, during extended very heavy or torrential rainfall periods that these drainage systems will be subjected to water flow from both on-site and off-site areas.

Conclusions and Recommendations: Much of this site is geologically suitable for use as a sanitary landfill. This conclusion is predicated on the following:

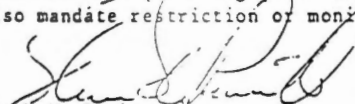
1. The thick mantle of silty, clayey soil which covers most of the site.
2. The absence of shallow groundwater.
3. The general absence of a shallow bedrock surface as indicated by the drilling.
4. The absence of springs and streams on the site.

The use of this site for landfill disposal, as proposed, is subject to the following restrictions and conditions:

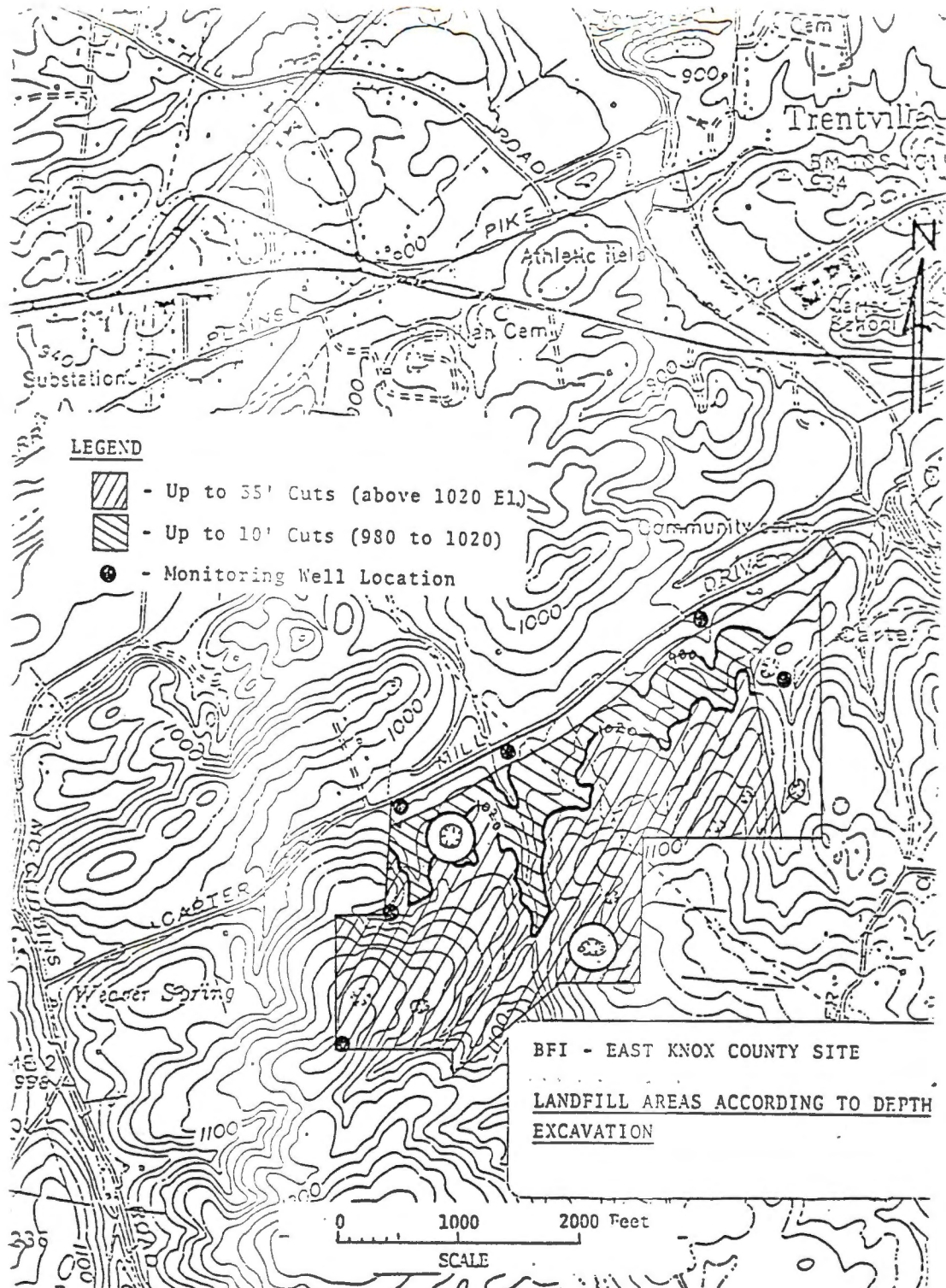
1. The areas approved for landfilling are indicated on an attached map according to depth of excavation and elevation restrictions as follows:
  - A. On that part of the site above the elevation of 1020 feet (MSL datum), excavations shall not exceed thirty-five (35) feet in depth below the existing natural land surface, and these excavations may not extend below the elevation of 1010 feet.
  - B. On that part of the site between elevations 1020 and 980 feet, excavations shall not exceed ten (10) feet in depth below the existing natural land surface, and these excavations may not extend below the elevation of 980 feet.
2. Landfill disposal is prohibited in the following areas:
  - A. Any part of the site below the elevation of 980 feet.
  - B. Any part of the site within two-hundred (200) feet from the center-line of Carter Mill Drive in order to facilitate proper drainage control.
  - C. The drainage area and associated sinks near the eastern boundary of the site (see maps).
  - D. Within a radius of two-hundred (200) feet from the center of the sink located near the southwest corner of the Amburn tract (see maps).
  - E. Within a radius of two-hundred (200) feet from the center of the large depression located near the northwest corner of the Ambrister tract on the south side of Carter Mill Drive (see maps).

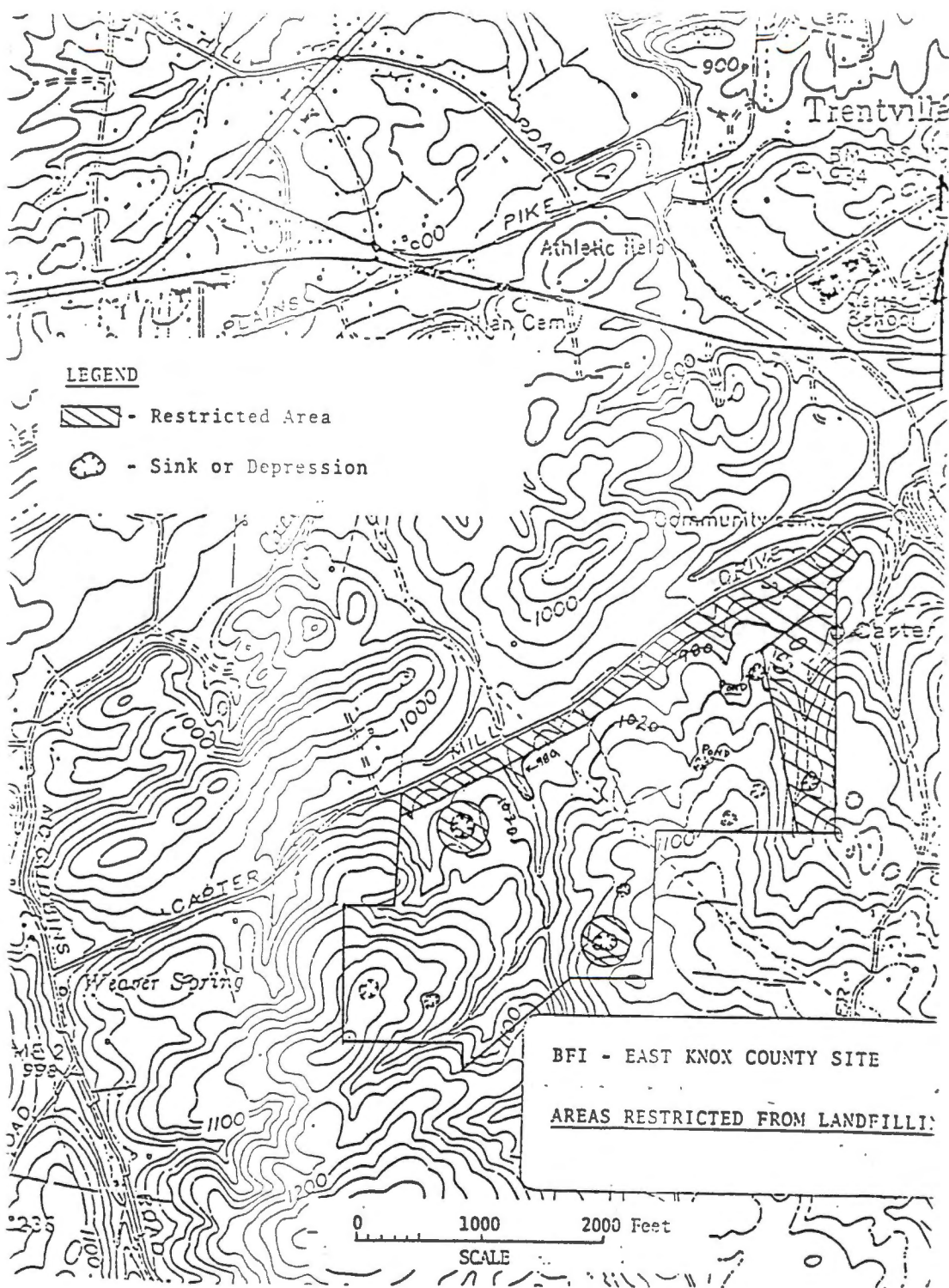
3. The landfill must be designed and operated so as to preclude abnormal run-off and erosional problems. Sediment ponds and diversion structures or other suitable means must be utilized as necessary to prevent the siltation of area streams and adjoining properties.
4. Surface water flow (run-off) may not be impeded in a manner which affects the normal run-off from off-site areas. All run-off which originates off-site must be provided free and open drainage and not impounded beyond the site boundaries.
5. If bedrock is exposed in landfill excavations, it must be re-covered with at least four (4) feet of compacted clay soil. Any such exposures, as well as any other unusual rock or soil conditions, water seeps, etc., must be immediately reported to this office.
6. Groundwater monitoring is required if this site is to be utilized for landfilling. The tentative locations for six (6) monitoring wells are indicated on an attached map. A list of monitoring parameters and a sampling schedule are also attached.
7. Certain area springs, in particular the Carter Cave and Weaver springs, must also be monitored provided that permission for such monitoring will be granted by the owners of the springs. Other springs may be specified by the Division.

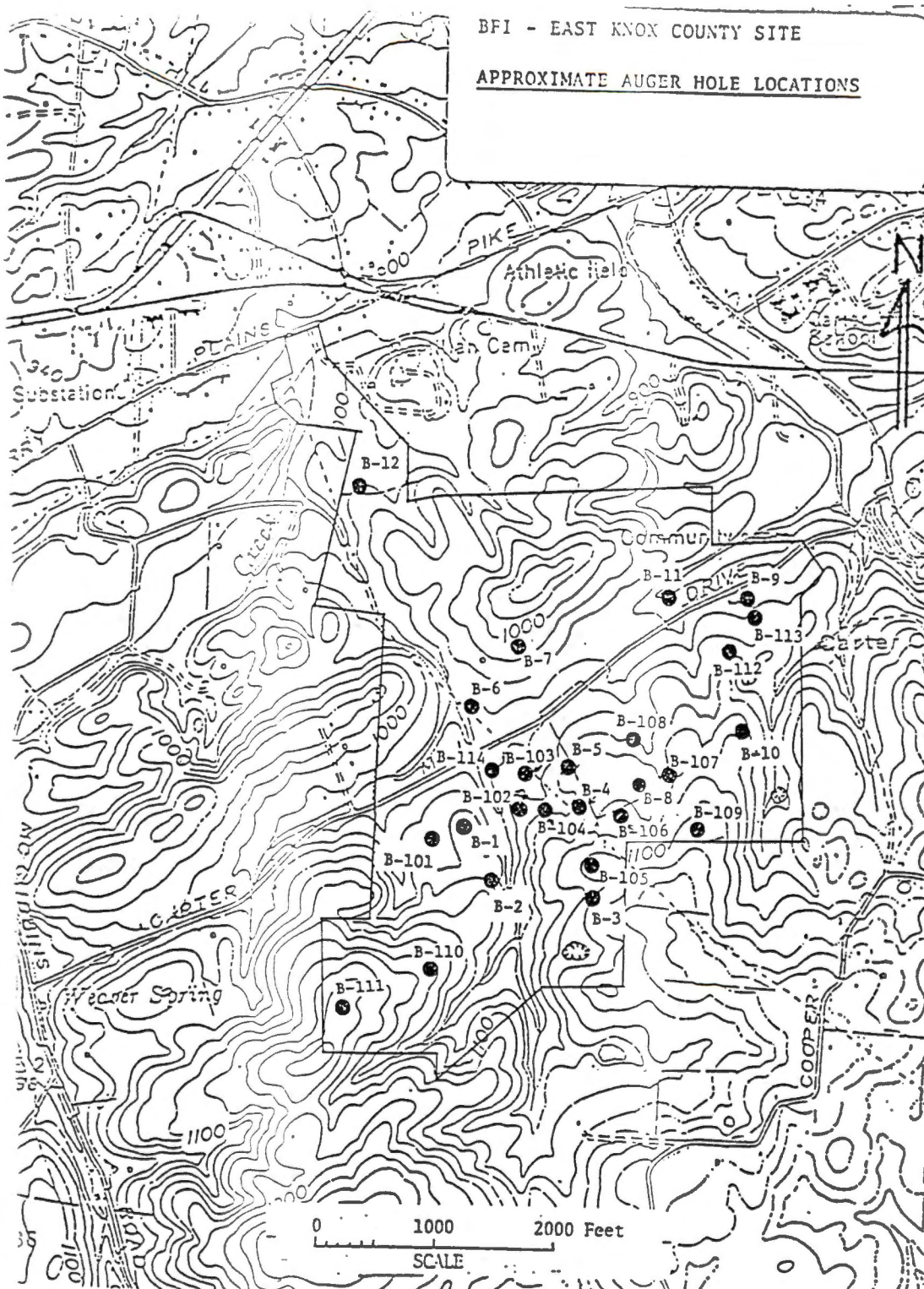
The aforesaid restrictions and the monitoring program are subject to change as required by the Division of Solid Waste Management. Future site conditions, operating problems, or changes in waste characteristics may also mandate restriction or monitoring changes.

  
Glenn N. Pruitt  
Environmental Specialist/Geologist  
Division of Solid Waste Management

GNP:pjl DSW3







#### **Appendix 4. History of the Carter Landfill Case**

THE KNOX COUNTY ADMINISTRATIVE REVIEW OF THE PROPOSED  
CARTER LANDFILL SITE--A CHRONOLOGY OF EVENTS

In October, 1986, BFI purchased an option 350 acres on SE/S Strawberry Plains Pike, NW&SE/S Carter Mill Drive, West of Carter School Road. Shortly afterward, BFI applied for the state permit to locate a landfill on 180 of the 350 acres. In late October, State Geologist Glenn Pruitt gave preliminary okay for the landfill site but recommended test drilling before a final conclusion (Appendix 3. Report of Geologic Investigation).

Unlike some other Tennessee communities that have very specific zoning controls on landfills, Knox County requires only that landfills get approval by the Metropolitan Planning Commission (MPC) and Knox County Commission under "use on review" proceedings. County zoning law states that the main standard for that proceeding is approval by the State Department of Health and Environment.

In December, the residents of the Carter/Pascall community learned of the intentions of BFI to put a landfill in their community and flooded the MPC with their objections. In response to the residents' objections, MPC Executive Director Sue Adams directed her staff to study some proposed changes to the county zoning law that would place more local restrictions on landfills. The study began in January and by February the MPC staff had developed a proposal for new standards based on the Tennessee Department of Health and Environment proposed solid waste management regulations.

The proposal stated that new landfills would be approved through the use-on-review process used in rezoning which would include an assessment of the impact of traffic and the roads to be at the site.

The proposal would require landfills to be not less than:

- 500 feet from homes unless the owner agrees to a shorter distance in writing.
- 1,000 feet from a residentially zoned area.
- 2,500 feet from schools or recreational areas.
- 500 feet from wells.
- 200 feet from boundaries of streams and lakes.
- 50 feet from property lines.

On February 12, the MPC considered the proposed amendments to the Knox County zoning resolution regarding the regulation of sanitary landfills. A motion was passed to send the matter to the County Commission for study. Gary Davis, representing the Citizens Against Pollution, asked that a moratorium be imposed on any new landfills in the county during the study, but this motion failed (minutes of February 12 MPC meeting).

On February 22, 1987, BFI filed a request for a use-on-review permit. In anticipation of the MPC hearings, John King, an attorney representing BFI, sent a letter to the County Commissioners to demonstrate the need for a new landfill site and the suitability of the site on Carter Mill Drive under the state regulations. This letter was dated March 3, 1987.

Gary Davis, representing CAP, sent a letter to Sue Adams, March 4, asserting that BFI had not met the requirements to receive a state

permit. In addition, CAP asked that the use-on-review criteria for sanitary landfills should be expanded and made more specific in the zoning resolution.

#### THE FIRST MPC MEETING

The MPC met on March 12 to consider the BFI request with John King arguing that BFI had met the state requirement for the permit. CAP representatives expressed their concerns about traffic problems, odor, health risks, property values, the proximity to a school and recreation area and the potential for groundwater pollution.

There was also testimony introduced by Commissioner Joe McMillian stating that the Chestnut Ridge landfill had enough capacity to operate for nine years given the present volume of waste and that the Knox County incinerator project would be in operation by 1991. At the present time, Waste Management, Inc., who operates the Chestnut Ridge landfill has the garbage disposal contract with the City of Knoxville. Commissioner McMillian, who represents the Carter area, suggested that BFI is requesting a permit to build a landfill so they can bid on the city's disposal contract. "There is not a garbage crisis in the City of Knoxville or in the County of Knox," McMillian said. "There is a crisis as far as BFI is concerned to make more bucks."

BFI currently has a landfill off Rutledge Pike that has an estimated one or two more years of use. After that time, they will have to use the Chestnut Ridge landfill owned by Waste Management. On March 12, the MPC voted in favor of the petition 7-5-1. On March 17, Gary

Davis on behalf of Paschal Carter Memorial Park Association filed an appeal of the MPC decision.

#### THE FIRST COUNTY COMMISSION MEETING

On April 20, 1987, the Knox County Commissioners met to consider two items with respect to the Carter landfill issue: 1) the MPC staff proposed amendments to the Knox County zoning ordinance regarding the regulation of sanitary landfills; and 2) the appeal by CAP, Pascal Carter Memorial Park Association, of the MPC approval of the request by BFI of use permit for a sanitary landfill. The commissioners voted to adopt the zoning amendments regarding the regulation of sanitary landfills. With respect to the appeal of the use-on-review the Commission voted to send the appeal of the use-on-review back to the MPC for study under the newly adopted sanitary landfill regulation.

#### THE SECOND MPC MEETING

On June 11, 1987, the Metropolitan Planning Commission reviewed the BFI request for permit to build a landfill in the Carter community under the new landfill regulations approved by the County Commission on April 20, 1987. The MPC determined that the proposed BFI site did not meet the new regulations as adopted by the County Commission on April 20, 1987.

#### THE SECOND COUNTY COMMISSION MEETING

On July 20, 1987, the Knox County Commission voted 15-0 to deny the BFI application for a use permit to build a landfill in the Carter

community based upon the ruling by the MPC that the request did not comply with the new landfill regulations.

#### THE CARTER LANDFILL CASE AS OF MARCH, 1989

"The issue of whether BFI will be permitted to build a landfill in the Carter community will probably be decided by the courts," said Gary Davis, attorney for the Carter Citizens Against Pollution (phone conversation, 1989). Davis also stated that the BFI request for permit does not meet the old or new county landfill guidelines. John King, attorney for BFI, argues that the application does meet the state landfill regulations (phone conversation, March, 1989). The Carter landfill case is awaiting a trial date to resolve the issue.

**Appendix 5. Survey Questionnaire for Carter Landfill Study**

QUESTIONNAIRE REGARDING THE PROPOSED BFI LANDFILL

SECTION I.

First we need to ask some questions about your residence.

1. Do you own or rent your home?

1= own      0= rent

2. Approximately how many years have you lived in the Carter community?

- |                     |                                      |
|---------------------|--------------------------------------|
| 1. less than 1 year | 3. more than 5 but less than 15 yrs. |
| 2. 1 to 5 years     | 4. more than 15 years                |

3. What is your main water source for drinking supplies?

- |               |                  |
|---------------|------------------|
| 1. well-water | 3. bottled water |
| 2. city water |                  |

4. Approximately how many miles is your residence from the proposed BFI landfill? (Please see attached map)

-----

5. How many persons reside in your household?

- |                  |                  |
|------------------|------------------|
| 1. one to two    | 3. five to six   |
| 2. three to four | 4. more than six |

## SECTION II.

7. Everyone knows that garbage has to go somewhere. Imagine a hypothetical situation where county residents could make annual payments (in the form of taxes or higher prices) into a fund which would enable governments to locate landfills away from residential areas, or to use more environmentally suited methods (e.g. recycling programs) for disposing of garbage. In this section, we would like to know how much it is worth to you to insure that a landfill is not located in your area.

In order to do this, please look at the Payment cards attached to the questionnaire. Find the card which corresponds to your 1987 before tax household income, and circle the maximum amount that your household would be willing to pay to insure that a landfill is not located in near your residence. Since this is not something we usually think about, we have included on the Payment cards what the average household like yours pays in taxes or higher prices each year for some other types of public programs. Once again, I would like to remind you that this interview is completely confidential and that your name will never be associated with your answers.

8. WHAT IS THE ABSOLUTE MOST THAT YOU WOULD BE WILLING TO PAY EACH YEAR TO ENSURE THAT A LANDFILL IS NOT LOCATED IN YOUR AREA?

\$ \_\_\_\_\_

9. If you answered \$0 to question number 8, please indicate the reason.

1. I can't afford to pay anything.
2. I object in principle to paying anything.
3. I do not believe there are any dangers from landfills.
4. I plan to leave the area regardless of whether the landfill is built.
5. other, specify \_\_\_\_\_.

SECTION III.  
Opinion About Pollution Policies

10. The following statements pertain to pollution control and pollution costs. Please read the statement and circle the one you agree with most.

1. Protecting the environment is so important that pollution control requirements and standards cannot be too strict and continuing improvement must be made regardless of the cost, or

2. we have made enough progress on cleaning up the environment so we should now concentrate on holding down costs rather than requiring stricter controls, or

3. Pollution control requirements and standards have gone too far and they already cost more than they are worth.

4. BETWEEN 1 AND 2.

5. DON'T KNOW

11. How concerned are you about the health risks from the proposed BFI landfill?

1. VERY CONCERNED

2. SOMEWHAT CONCERNED

3. DO NOT FORESEE ANY RISKS

4. DON'T KNOW

## SECTION IV.

This last section asks a few questions about the head of the household.

12. What is your age?

- |                        |             |
|------------------------|-------------|
| 1. 17 years or younger | 5. 46 to 55 |
| 2. 18 to 25            | 6. 56 to 65 |
| 3. 26 to 35            | 7. 66 to 75 |
| 4. 36 to 45            | 8. over 75  |

13. What is your sex?

1 = female      0 = male

14. What is the level of education that you have completed?

1. less than high school
2. some high school
3. high school graduate
4. some college or technical training
5. college graduate
6. post graduate work in college

CLOSING: Thank you for your time and cooperation.

PAYMENT CARD

ANNUAL HOUSEHOLD INCOME BEFORE TAXES  
UNDER \$10,000

PAYMENT CARD

ANNUAL HOUSEHOLD INCOME BEFORE TAXES  
\$10,000 - \$19,999

(AVERAGE ANNUAL AMOUNT IN 1982 TAXES AND PRICES  
PAID FOR SOME PUBLIC PROGRAMS)

|                                    |                         |                        |
|------------------------------------|-------------------------|------------------------|
| \$ 45                              | \$120                   | \$270                  |
| — POLICE<br>AND FIRE<br>PROTECTION |                         |                        |
| 50                                 | 130                     | 280                    |
| 55                                 | 140                     | 290                    |
| 60                                 | 150                     | 300                    |
| 65                                 | 160                     | 320                    |
| 70                                 | 170                     | 340                    |
| 75                                 | 180                     | 360                    |
| 80                                 | 190                     | 380                    |
| 85                                 | 200                     | 400—DEFENSE<br>PROGRAM |
| 90                                 | 220                     | 420                    |
| 95                                 | 240—PUBLIC<br>EDUCATION | 440                    |
| 100—ROADS AND<br>HIGHWAYS          | 250                     | 460                    |
| 110                                | 260                     | 480                    |

(AVERAGE ANNUAL AMOUNT IN 1982 TAXES AND PRICES  
PAID FOR SOME PUBLIC PROGRAMS)

|                     |                                    |                      |                     |
|---------------------|------------------------------------|----------------------|---------------------|
| \$ 0                | \$ 90                              | \$295                | \$550               |
| 5                   | — POLICE<br>AND FIRE<br>PROTECTION | 310                  | 565                 |
| 10                  | 110                                | 325                  | 580                 |
| 15                  | 120                                | 340                  | 595                 |
| 20                  | 130                                | 355                  | 615                 |
| 25—SPACE<br>PROGRAM | 140                                | 370                  | 635                 |
| 30                  | 150                                | 385                  | 655                 |
| 35                  | 160                                | 400                  | 675                 |
| 40                  | 170                                | 415                  | 695                 |
| 45                  | 180                                | 430                  | 715                 |
| 50                  | —ROADS AND<br>HIGHWAYS             | 445                  | 735                 |
| 55                  | 205                                | 460                  | 755                 |
| 60                  | 220                                | 475                  | 775                 |
| 65                  | 235                                | 490                  | 795                 |
| 70                  | 250                                | —PUBLIC<br>EDUCATION | 815                 |
| 75                  | 265                                | 505                  | —DEFENSE<br>PROGRAM |
| 80                  | 280                                | 520                  | 835                 |
|                     |                                    | 535                  | 855                 |

## PAYMENT CARD

## ANNUAL HOUSEHOLD INCOME BEFORE TAXES

\$20,000 - \$29,999

## PAYMENT CARD

## ANNUAL HOUSEHOLD INCOME BEFORE TAXES

\$30,000 - \$49,999

(AVERAGE ANNUAL AMOUNT IN 1982 TAXES AND PRICES  
PAID FOR SOME PUBLIC PROGRAMS)

|     |       |       |        |
|-----|-------|-------|--------|
| 0   | \$190 | \$620 | \$1140 |
| 10  | 210   | 650   | 1180   |
| 20  | 230   | 680   | 1220   |
| 30  | 250   | 710   | 1260   |
| 40  | 270   | 740   | 1300   |
| 50  | 290   | 770   | 1340   |
| 60  | 310   | 800   | 1380   |
| 70  | 330   | 830   | 1420   |
| 80  | 350   | 860   | 1460   |
| 90  | 380   | 890   | 1500   |
| 100 | 410   | 920   | 1540   |
| 110 | 440   | 950   | 1580   |
| 120 | 470   | 980   | 1620   |
| 130 | 500   | 1010  | 1660   |
| 140 | 530   | 1040  | 1700   |
| 150 | 560   | 1070  | 1740   |
| 170 | 590   | 1100  | 1780   |

(AVERAGE ANNUAL AMOUNT IN 1982 TAXES AND PRICES  
PAID FOR SOME PUBLIC PROGRAMS)

|     |       |        |        |
|-----|-------|--------|--------|
| \$0 | \$450 | \$1445 | \$2720 |
| 15  | 480   | 1520   | 2805   |
| 30  | 510   | 1595   | 2890   |
| 45  | 540   | 1670   | 2975   |
| 60  | 570   | 1745   | 3060   |
| 90  | 600   | 1820   | 3145   |
| 120 | 630   | 1895   | 3230   |
| 150 | 695   | 1970   | 3315   |
| 180 | 770   | 2045   | 3400   |
| 210 | 845   | 2120   | 3485   |
| 240 | 920   | 2195   | 3570   |
| 270 | 995   | 2270   | 3655   |
| 300 | 1070  | 2345   | 3740   |
| 330 | 1145  | 2420   | 3825   |
| 360 | 1220  | 2495   | 3910   |
| 390 | 1295  | 2570   | 3995   |
| 420 | 1370  | 2645   | 4080   |

DEFENSE  
PROGRAM

## PAYMENT CARD

ANNUAL HOUSEHOLD INCOME BEFORE TAXES  
\$50,000 and over(Average annual amount in 1982 taxes and prices  
paid for some public programs)

|                       |                            |                            |                            |
|-----------------------|----------------------------|----------------------------|----------------------------|
| 0                     | 1150                       | 3660                       | 7410                       |
| 25                    | 1250                       | 3860                       | 7600                       |
| 50                    | 1350 police<br>and fire    | 4260                       | 7910                       |
| 100                   | 1450 protection            | 4460                       | 8100                       |
| 150                   | 1660                       | 4860                       | 8600                       |
| 200                   | 1760                       | 5060                       | 8910                       |
| 250                   | 1860 roads and<br>highways | 5250                       | 9160                       |
| 300                   | 2060                       | 5460                       | 9410                       |
| —space<br>350 program | 2260                       | 5660                       | 9600                       |
| 450                   | 2460                       | 5860                       | 9910                       |
| 550                   | 2560                       | 6060                       | 10160                      |
| 650                   | 2860                       | 6250                       | 10410                      |
| 750                   | 3060                       | — public<br>6460 education | 10660                      |
| 850                   | 3260                       | 6660                       | 10910                      |
| 950                   | 3460                       | 6910                       | — defense<br>11160 program |
| 1050                  | 3660                       | 7160                       | 11410                      |

## VITA

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Education

Doctor of Philosophy in Resource Economics, University of Tennessee, May, 1989. Specialization in Environmental Policy, Economic Theory and Econometrics.

Master of Science in Resource Economics, University of Tennessee, 1984. Specialization in Environmental Economics and Economic Theory.

Master of Business Administration, University of Tennessee, 1978. Specialization in Economic Theory.

Bachelor of Arts in Sociology, University of Tennessee, 1973.

Teaching Experience

Assistant Professor, Department of Economics, University of Tennessee at Chattanooga, June, 1982, to May, 1987. Course titles: Principles of Economics, Intermediate Microeconomics.

Teaching Assistant, Department of Agricultural Economics, University of Tennessee, fall, 1981. Course title: Natural Resource Economics.

Research Experience

Postdoctoral Fellowship, Energy, Environment, and Resources Center, University of Tennessee, November, 1989, to present. Research conducted on solid waste management policy issues.

Research Assistant, Department of Agricultural Economics, University of Tennessee, December, 1980, to December, 1981, and May, 1987, to November, 1988. Dissertation title: "A Contingent Valuation Estimation of the Value to the Carter Community of Avoiding a Municipal Landfill."

Research Associate, The Institute for Energy Analysis, Oak Ridge Associated Universities, Oak Ridge, Tennessee, June, 1979, to

December, 1980. Primary area of research: Energy Policy Analysis.

#### Administrative Experience

Head, Administrative Services, Oak Ridge Associated Universities, May, 1978, to June, 1979. Responsibilities: supervised all administrative sections of the organization, including internal auditing, security, travel, property management and telecommunications.

Administrator, Child Support Enforcement Division of the Davidson County District Attorney's Office, May, 1977, to May, 1978. Responsibilities: established and managed the administrative aspects of the division.

#### Honor Societies and Organizations

The International Economics Society of Omicron Delta Epsilon.  
The International Agricultural Society of Gamma Sigma Delta.  
The American Economics Association.  
The American Agricultural Economics Association.

#### Publications and Presentations

Douglas, Peggy (September 10 and 16, 1988). "Deep Ecological Solution to the Garbage Problem," seminar to the ALF School of Chattanooga, Tennessee.

Douglas, Peggy (October 10, 1988). "The Social Costs of Municipal Landfill," presentation to Special Joint Legislative Committee on Hazardous Waste, Nashville, Tennessee.

Douglas, Peggy (October 11, 1988). "Resource Needs for Tennessee's Solid Waste Management Strategies," presentation to Tennessee Governor's Roundtable on Solid Waste.

Douglas, Peggy (January 21, 1989). "Deep Ecology," presentation to IJAMS Audubon Nature Center, Knoxville, Tennessee.

Douglas, Peggy (February 16, 1989). "Garbage and the Greenhouse Effect," invited discussant in WATT 89 Conference, Knoxville, Tennessee.

Douglas, Peggy (February 17 and 18, 1989). "The Social and Political Aspects of Solid Waste Management Strategies," invited discussant in Tennessee Recycling Conference, Nashville, Tennessee.

Douglas, Peggy, and Richard Meunier. "Legal Aspects of Energy Emergency Planning," report to the Oak Ridge National Laboratory, April, 1981.

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### References

Dr. William Colglazier, Director, Energy, Environment and Resources Center University of Tennessee, Knoxville, 615/974-4251.

Gary David, Senior fellow, Energy, Environment and Resources Center, University of Tennessee, Knoxville, 615/974-4251.

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