Economic Effects of Hazardous Chemical and Proposed Radioactive Waste Landfills on Surrounding Real Estate Values

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Abstract. **The results of the study of residential housing prices of homes located in the proximity of a large toxic chemical waste landfill in the Toledo, Ohio, area for 1986–1990, strongly suggest a distinct negative impact on sale prices for homes located within 2.6 miles of the existing site, and a diminishing impact before a distance of 5.75 miles is reached. Within the 0–2.6 mile range to the Envirosafe Landfill, a $14,200 premium was found for each mile a house was located away from the Landfill. The premium is greater than found in other studies. A second proposed site in 1989, for low-level radioactive wastes, showed a clear, initial negative impact on housing sales prices upon announcement, but the negative effect on prices dissipated soon after extensive public resistance became evident and caused the proposal to be cancelled.**

Introduction

This article examines the effects of landfills containing hazardous waste on local housing values. This study differs from previous works because it utilizes an operating landfill explicitly licensed by the federal government to accept only hazardous waste. It is one of eleven in the U.S. created for this purpose. In addition, the site has propinquity to a major metropolitan area (Toledo, Ohio).

Prior studies often focused on both general purpose landfills and industrial landfills, some of which were identified by environmental authorities as containing hazardous wastes, and posing a possible health risk. Many of these landfills are now closed pending cleanup action. Hazardous materials were sometimes incidental to disposal sites for household refuse. According to the Ohio Environment Protection Agency data, in 1990, there were approximately 1,100 actual sites identified as warranting investigation as alleged hazardous substance sites (Ohio EPA [16]).

Additionally, the study considers the effect on house prices in the Toledo area of a proposed low-level radioactive wastes landfill designed to be the exclusive recipient of materials from eight midwestern states.

This study specifically examines the marginal price-distance impact on housing values of locating a regional hazardous waste site in an urban area. It will offer important insights to policy makers, mortgage lenders, developers, fee appraisers, tax assessors, and housing consumers.

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Background

With passage of the Comprehensive Environmental Response, Compensation, and Liability (42 U.S.C.A. Sec. 9601–0675), and Superfund Amendments and Reauthorization Act of 1986, directing cleanup of hazardous waste contamination of real estate, real estate owners are thrust into uncertainty with proposed real estate transactions, whether a purchase or sale. Owners are responsible for cleanup, regardless of whether they were originally the parties responsible for contamination. Consequently, buyers are becoming wary of potential liability (Pilko and Geer [18]; Rubin [21]). As potential owners in a foreclosure proceeding, lenders are concerned about their liability and are requiring buyers to take necessary actions to protect them (Baker [2]; Lando [10]; Ryan [22]).

Faced with this enormous potential liability, banker lenders are demanding, prior to any mortgage financing commitments, reasonable efforts by the seller and buyer to demonstrate that no hazardous wastes are contaminating the property (Shumate [24]). Additionally, many mortgage lenders are requiring an Environmental Protection Lien Endorsement prior to loan commitment by a title insurance company for residential mortgages.

Public consensus has long held that landfills containing hazardous wastes are not a favorable usage of land (Mitchell [14]; Smith and Desvousges [25]; Carter [4]). Interestingly, past hedonic studies have not strongly supported a variety of different proxy variables that would explain this hypothesis or been able to statistically capture the disamenity effects of these sites (Adler et al. [1]; Schulze et al. [23]; Kohlhase [9]).

The Adler and Schulze studies both used distance from the landfills in their studies as the focal variable, while the Kohlhase [9] study examined the Houston market from 1976–1985 to determine the impact of announcements of ten Houston sites on the EPA's National Priority List on local property values, both from an awareness and a distance perspective.

Another recent study by Michaels and Smith [13] utilized a time variable to measure a distance-price relationship in housing in the Boston area. They used an interaction variable between time and distance to the site. Arguably their results may be seen as more consistent with a relationship with time than with the distance to the landfill. The authors cautioned the reader that their results "illustrate the difficulties developing proxy measures for the disamenity effects associated with hazardous waste sites." Further, they argue the need for defining complex markets into submarkets in order to observe reliable relationships.

Case Study: Toledo Metropolitan Area

The Toledo Metro area offers an interesting research laboratory to study the effects of proximity of toxic waste landfills on residential housing prices. The City of Oregon, located on the east side of the Toledo metropolitan area, hosts a landfill operated by Envirosafe, Inc. The landfill is unique since it accepts a low-level category of hazardous (toxic) wastes from throughout the Eastern United States. Applicable state and various federal agencies confirm its proper design and continued safety; nevertheless, among some concerned citizens groups an ebb and flow debate clouds the question of the facility's long-term safety.

In late 1989, a second hazardous waste disposal facility was announced by the State of Michigan, which coincidentally was located close to the northwest side of the Toledo, Ohio metropolitan area. Although the site was far from the population centers of Michigan, it was adjacent to the Western Toledo SMSA. Ultimately, a protest from residents of Toledo and surrounding areas defeated the proposal. The intense citizen challenge and extensive media coverage offered a unique opportunity to measure the impact of a proposed hazardous waste facility on the local residential real estate market.

Theory

The theoretical framework underlying this study encompasses two aspects: inputing the value of services provided by housing, and the efficiency of price adjustment of housing to changes in market conditions.

Housing provides a stream of utility to the user taking the forms of shelter and "psychic income". The former reflects the cost of renting the equivalent form of shelter for consumption by the user. The latter is an intangible form of consumption, i.e., the positive emotional feeling provided by owning one's home. This intangible element refers to the situs aspect of real estate. It describes such characteristics as a nice view of sunsets, many shade trees, unique architecture, or a clean neighborhood. All of these attributes enter into the value equation.

The value of the housing asset to an individual at a point in time becomes a discounted value of a stream of benefits over the time the consumer uses it. Assuming a long-term stream of benefits, the equation describing the relationship is the following.

$$V_i = \sum_{t=0}^{n} \left(\frac{B_t}{(1+r)} \right),$$

where

V_i = the valuation of the ith house at time t;
B_t = the stream of benefits accruing to individual i to infinity;
r = an appropriate discount rate reflecting the risks of receiving the stream of benefits.

This equation shows that the house value varies directly with the magnitude of benefits received (B_t), and inversely with the discount rate, r. As r increases, reflecting increased risk at time (t), the value of the house decreases, and vice versa. This basic relationship is well documented in finance and real estate literature (Rosen [20]; Ferri [8]; Lang and Jones [11]; Noland [15]; Edmonds [5]; Blackley et al. [3]; Michaels and Smith [13]).

The second part of the theory deals with the efficiency of real estate markets, i.e., the rapidity of market price changes to new information. This theory draws heavily on work first set forth by Fama [6] in studies of securities pricing behavior. Specifically, market efficiency "means that new information is widely, quickly, and cheaply available to investors, that this information includes what is knowable and relevant for judging securities and is rapidly reflected in their prices" (Lorie and Brealey [12]).

Methodology

Two landfill locations are studied, one a potential new site (radioactive) and an existing site (chemical). Actual real estate sale prices in the greater Toledo, Ohio area from court house transactions data were used to establish relative benchmarks of housing prices before the announced location of the nuclear dump site, and afterward. Adjacent southeast Michigan housing prices are excluded because the area is largely undeveloped rural farm lands without a significant real estate sales database for housing. In addition to descriptive statistics regarding housing trends, a series of regression models were constructed.

This study is accomplished through use of a hedonic model. At the most general level, the hedonic price function is a modeling strategy that alters the definition of market equilibrium to describe an economic agent's choices among heterogeneous commodities (Michaels and Smith [13]; Palmquist [17]). This framework maintains that attributes of the commodities can be identified and that they can provide the motivation for an individual's choices. Additionally, the framework assumes a sufficient variation exists in the mixes of these characteristics across goods to assure that a continuous price function can be defined to describe the prices required for an equilibrium in the market. Therefore, the hedonic price function is the relationship describing the manner prices must relate to characteristics for an equilibrium matching to be realized (Rosen [20]). This hedonic model is used to establish an equilibrium condition among housing units at varying distances from hazardous waste sites.

A number of macroeconomic variables including local unemployment rates and local housing interest rates, number of homes on the market, number and severity of any safety-related incidents at the dump site, and local population trends ordinarily might be relevant in periods of wide economic variability. However, the period of the study was marked by extreme economic stability. For example, FHA mortgage rates ranged from 9.91% in 1986, to 10.28% in August 1990, peaking at 10.49% in 1988 (Board of Governors Federal Reserve [7]). Similarly, unemployment rates remained relatively stable during the period, as did population trends. Research showed no occurrence of a safety-related accident at the landfill during the five-year period of study. An accident might induce fear or concern by home owners or buyers in proximity of the landfill, and transmit abnormal price variations to the housing markets.

A neighborhood centroid scheme was used to study the economic impact. Linear distances between each house sold and the nearest landfill were recorded and entered in the databases for the Envirosafe and the proposed Riga sites.[1] Because Kohlhase [9] suggested a nonlinear distance relation, this study subdivided the sample into concentric circles, each containing about one-third of the data. Nonlinearities would show as differences in coefficient estimates between the groups. Since Lake Erie and associated wetlands are approximately two miles to the north of Envirosafe, residential housing lies mainly south of the landfill.

A control sample was selected from a similar neighborhood area in terms of income, age, and housing size, located well south of the landfills. Forty-nine sales were identified based on similarity and distance from the Envirosafe site and other known polluting sources.

Multiple regression models were specified using a dependent variable, "house sale prices" of individual housing units from 1986 through mid-1990, and various independent variables, e.g., house sale prices, distance from the dump site, living space,

number of rooms, lot size, bath room configuration, and porches. The independent variables reflected increasing utility to the homeowner, i.e., normally a full basement is more desirable than a partial basement, which is in turn more desirable than a slab, or a crawl space. By the same criteria, an enclosed porch is considered more desirable than an open porch. A model was specified for each year in order to capture transitional changes in variable relationships more accurately than using a single model with an independent variable for time. A total of 1,312 and 1,237 transactions were used for the Riga Township site and the Envirosafe site, respectively.

Four primary research hypotheses analyzed in this study are presented below:

1. The establishment of a nuclear/toxic waste dump does not decrease housing values in the surrounding neighborhoods of the dump site.
2. The establishment of a toxic waste dump does not significantly decrease housing prices.
3. The establishment of a nuclear waste dump does not significantly decrease housing prices for more than a three-month post-announcement period.
4. The establishment of a toxic waste dump does not significantly decrease housing prices for more than a three-month post-commencement period of operation. Post-commencement may be defined as the date of the first incoming waste shipment.

The Results

A series of regression models were computed using the housing sales data. The dependent variable was the actual sales price transaction. A number of independent variables were examined for their impact on the robustness of the model. The various models were modified to best identify the effects of proximity to the landfill on sales prices, recognizing the existence of multicorrelation. Data were available for the following independent variables: house-level descriptor (e.g., single level, bi-level); house-use (e.g., single family, condominium); construction type (e.g., brick, frame); living space in square feet; number of rooms; number of bedrooms; number of full baths; number of half baths; age of house; central air; type of finished basement; type of enclosed porch, patio or deck; garage size and type; number of outbuildings; lot size; pool; and fireplace. Each of the variables was coded to reflect greater or lesser utility to the owner.

Envirosafe Landfill for Toxic Wastes

The number of independent variables was reduced by using stepwise regression to identify variables, from among those available, explaining the greatest amount of variation in the dependent variable. Multicollinearity was identified as a problem. If there is considerable multicorrelation in regression computations, its presence greatly erodes the effectiveness and usefulness of the regression. Appropriate statistical tests were done to measure the extent of multicorrelation, and in an effort to eliminate some of it in the entire model, a more parsimonious model was specified. It was regressed on

only three variables, *Dist, Livspc*, and *Hbaths*. This more concise model was more appropriate because it tended to show higher statistical R^2's than did several other three-variable models employing the *Dist* variable.[2]

The model was computed using the data for the entire five-year period for three distance or centroid ranges[3] from the landfill, i.e., 0–2.6 miles, 2.61–5.75 miles, and greater than 5.75 miles. Rationale for the three distance ranges hinged on obtaining approximately equal sample sizes within each range. Increasing the number of distance centroids to span uniformly shorter distances, produced unequal transactions per centroid largely because home sales are not uniformly distributed across the Toledo metropolitan area per unit of time.

The results of a control sample can serve to strengthen the interpretation given to the findings of the samples used to test the research hypotheses.[4] A control sample was collected of home sales occurring in 1989 and 1990. The houses included in the control sample were located seven or more miles south of the landfills. The *Dist* variable proved itself statistically nonsignificant in the control sample. This finding increases the credibility of results computed from the landfill samples, assuming they are found statistically significant and with the expected sign, in this case a positive sign.

The *Dist* variable in Equation 1.1 found in Exhibit 1 for 1986–1990 regression shows a value of 12.061. This means that within the 0–2.6 mile range, fore each mile the house was removed from the actual Landfill location, the sales price of the house increased $12,061, all else held constant. In other words, a house located two miles away from the Landfill, compared to a house located immediately adjacent to the Landfill, would be expected to sell for $24,122 more (i.e., 2 miles times $12,061). Extending this method of coefficient interpretation to the *Livspc* (living space in square feet) variable shows incremental square footage of living space adding $41 to the sales price of the house. A $41 per square foot value on a house is reasonable for the Toledo real estate market. The variable *Hbath* (half bath) with its coefficient of 16.306, indicates each half bath adds $16,306[5] to the sale price of a house located in the 0–2.6 mile range of the Landfill during 1986–1990, other variables held constant.[6]

Exhibit 1
Multiple Regression Models for Houses Located from 0–2.6 Miles, 2.6–5.75 Miles, and Greater than 5.75 Miles from Envirosafe Landfill Site, City of Oregon, Ohio, 1986–1990[a]

	Intcpt	*Dist*	*Livspc*	*Hbath*	R^2	*F*-Ratio	Std. Error
Equation 1.1							
0–2.6	−26.549	12.061	.041	16.306	.504	279.6	22.0
	(7.28)	(7.67)	(19.84)	(9.31)			
Equation 1.2							
2.6–5.75	−34.794	12.106	.035	11.337	.384	70.5	23.0
	(2.79)	(3.22)	(11.98)	(3.88)			
Equation 1.3							
5.75	14.451	−1.812	.052	14.548	.718	38.1	21.3
	(.66)	(1.28)	(8.64)	(2.55)			

[a] *T*-scores are in parentheses in absolute values.

Equation 1.2 presents an analysis of the Envirosafe data in the intermediate distance (2.6–5.75 miles) range for all five years of data. The distance from the landfill variable (*Dist*) is significant at the 1% level. Curiously, the signs on the coefficients, as well as their significance, are similar to those in the previous table, and coefficient interpretation would similarly follow. We expected the coefficient on the distance variable to decrease over this distance because we expected some degree of nonlinearity. Interpreting the coefficients in terms of dollar impact shows a $12,106 increase in value per mile more distant from the Landfill, a $35 per square foot value of living space in the house, and $11,337 premium per half bath in the house. Part of the reason for the stability of the estimates may be the fact that the price structure of the entire City of Oregon may be "tainted" by its proximity to the toxic landfill.

Equation 1.3 provides the regression for the final distance range from the landfill, 5.75 miles or more. These coefficient signs appear plausible. Additionally, houses located at distances greater than 5.75 miles from the Envirosafe Landfill show no downward pressure on the sales prices by the distance variable. This distance from the Landfill is greater than the traditional notion of living near landfills—"out of sight is out of mind". The data showed a strong statistical relationship between proximity to a landfill and sales prices of residential real estate, extending out to between 0 and 5.75 miles from the landfill site. This distance-price effect is much clearer than previous studies by Kohlhase [9], Michaels and Smith [13], or Reichert [19]).

Pricing Effects over Time

The data analysis has been refined to investigate the year-by-year effects of housing prices at three proximity ranges to the Envirosafe Landfill from 1986–1990. The purpose of this analysis is to identify whether there is increased sensitivity to the Envirosafe Landfill in recent years, particularly in 1990, on the heels of the controversial Riga Landfill announcement. Further, this allows the detection of nonlinear shifts due to time effects on housing prices. The tables primarily used to convey the results will be the *Saleamt* regressed on three-variable model, *Dist, Livspc*, and *Hbath*. This model tended to obtain the highest R^2. Where deemed useful, alternative models will be given.

In Equation 2.1 of Exhibit 2 are the results of a regression model for 1986, for home sales within 2.6 miles of the Envirosafe Landfill. The distance variable is significantly different from zero at the 0.01% level. Houses located within 2.6 miles of the landfill and selling in 1986 suffered some diminished price effect as a result of the proximity to the landfill. *Livspc* and *Hbath* variables were significant, with positive signs. Many of the homes are smaller and less costly, causing buyers who are attracted to homes of this price range to value the half bath feature. The R^2 for the model was 49%, and significant.

Equations 2.2, 2.3, and 2.4 continue the presentation of annual results for years 1987–1989. In all cases the distance coefficient is significant and with a positive sign. The variable's consistent pattern of significance and its positive sign indicates no change in the perception of the home buying public over the four-year period, i.e., that the Envirosafe Landfill presents less of a problem. Specifying the precise type of problem the public perceives resulting from the landfill's presence in the community is not possible to discern from the data.

Exhibit 2
Multiple Regression Models for Houses Located less than 2.6 Miles from Envirosafe Landfill Site, City of Oregon, Ohio, 1986, 1987, 1988, 1989, January through August 1990, Using Three Independent Variables[a]

	Intcpt	*Dist*	*Livspc*	*Hbath*	R^2	*F*-Ratio	Std. Error
Equation 2.1							
1986	−18.002	9.344	.035	13.685	.490	114.4	19.6
	(3.79)	(4.51)	(12.72)	(5.74)			
Equation 2.2							
1987	−26.184	9.301	.041	12.953	.551	85.2	18.7
	(4.21)	(3.58)	(11.04)	(4.43)			
Equation 2.3							
1988	−34.410	13.365	.047	16.154	.561	87.9	21.3
	(4.73)	(4.18)	(11.71)	(4.98)			
Equation 2.4							
1989	−29.297	14.205	.059	23.034	.505	66.4	25.0
	(3.41)	(3.75)	(9.21)	(5.51)			
Equation 2.5							
1990	−45.457	13.030	.059	11.460	.619	29.3	20.5
	(2.98)	(2.48)	(6.17)	(1.72)			

[a] *T*-scores are in parentheses in absolute values.

Exhibit 3
Multiple Regression Models for Houses Located 2.6 to 5.75 Miles from Envirosafe Landfill Site, City of Oregon, Ohio, 1986, 1987, 1988, 1989, January through August 1990, Using Three Independent Variables[a]

	Intcpt	*Dist*	*Livspc*	*Hbath*	R^2	*F*-Ratio	Std. Error
Equation 3.1							
1986	−9.013	7.416	.023	12.700	.288	19.8	22.8
	(.47)	(1.25)	(5.77)	(3.09)			
Equation 3.2							
1987	−37.516	10.106	.020	8.137	.320	13.1	24.5
	(1.30)	(1.21)	(3.77)	(3.22)			
Equation 3.3							
1988	−88.961	22.793	.053	19.309	.628	54.1	22.0
	(3.89)	(3.33)	(10.29)	(3.24)			
Equation 3.4							
1989	−6.428	5.596	.028	12.152	.311	10.4	19.5
	(.31)	(.89)	(3.94)	(2.15)			
Equation 3.5							
1990	−83.423	16.503	.081	−15.333	.763	16.1	14.9
	(1.80)	(1.25)	(6.91)	(2.05)			

[a] *T*-scores are in parentheses in absolute values.

As a cautionary note, the data used in the regression is for the first nine months of 1990, because the data-gathering phase of the study drew to a close on August 30, and the data analysis phase commenced. Consequently, the sample size for 1990 consisted of 59 observations, whereas the sample ranged from 190 to 215 observations in the previous years of the study.

In the distance range 2.6–5.75 miles from the Envirosafe Landfill, shown in Exhibit 3, there is no evidence of adverse impact of the Landfill on home sale prices. Note the dramatic decline in the ability of the three-variable model to explain variation in the dependent variable in this distance range relative to the under-2.6 mile range, shown in Exhibit 2.

Except for Equation 3.3, the findings for years 1987–1990 are nonsignificant for the distance coefficient, and *Livspc* and *Hbath* are consistently significant in the equations. For over-5.75 miles, the *Dist* variable was never significant. These results are not reported.

The Proposed Riga Township Landfill

The City of Sylvania is an upper middle class community that has experienced considerable residential building activity during the past decade. Sylvania borders Toledo on the west and lies south of the Michigan state line.

When it was announced that a low-level radioactive landfill was imminent on the Michigan side of the state's border in Riga Township, residents were shocked. Immediately following the announcement, local real estate experts predicted major negative impacts on Sylvania residential real estate markets should the landfill become a reality. The educated, professional residents mobilized an all-out effort to defeat the proposal. They employed a wide range of tactics including the use of political force at the state and national level. In the third quarter of 1990, the state of Michigan rescinded their proposal. These events provide a unique opportunity to measure the effects on real estate property values.

Data similar to that used in analyzing the Envirosafe Landfill's impact on residential properties were collected, with one exception. Because the objective of this investigation initially occurred in 1989, and extended into 1990, prior sales data was not deemed necessary. Riga Township overlaps and lies to the northwest of Sylvania Township. The western edge of the Sylvania City limit lies east of the western edge of the Riga Township border. Consequently, the bulk of existing Sylvania housing begins nearly two miles southeast of the eastern edge of Riga Township.

Equation 4.2 of Exhibit 4 presents the regression results for 1989, the year of the announcement. Surprisingly, the *Dist* variable is not significant, although its sign is positive, an expected occurrence. Two possible explanations for the nonsignificance are offered. First, the announcement effect occurred for only the last half of 1989, therefore, mitigating the full effect of the announcement. Second, the sample size is only eighty-seven sales in this distance range because the area encompassed by this distance range is relatively rural and it is a community exhibiting low turnover of homes. The small sample size, although above the generally acceptable statistical level recommended as the lower limit for use of the *t*-test, leaves some question of reliability of the findings.

The results for 1989 are found in Equation 4.2, and mirror the findings for 1990 which are given in Equation 4.3, including coefficient signs and significance of the variables.

Exhibit 4
Multiple Regression Models for Houses Located Less Than 2.6 Miles from Riga Township Landfill Site Proposal, near the City of Sylvania, Ohio, 1988 and 1989, January through August 1990, Using Three Independent Variables[a]

	Intcpt	*Dist*	*Livspc*	*Hbath*	R^2	*F*-Ratio	Std. Error
Equation 4.1							
1988	−13.217	−6.098	.078	−7.278	.748	57.3	24.7
	(.50)	(.61)	(12.62)	(.92)			
Equation 4.2							
1989	−32.050	5.780	.073	−2.700	.686	61.2	26.5
	(1.76)	(.81)	(12.39)	(.51)			
Equation 4.3							
1990	−5.643	2.211	.061	−1.773	.735	29.6	21.5
	(.23)	(.22)	(8.79)	(.21)			

[a]*T*-scores are in parentheses in absolute values.

Equation 5.2 of Exhibit 5 includes the regression results for 1989, for sales in the distance range 2.6 to 5.75 miles. The sample size is 310 sales units, reflecting a far more dense population than the sample size in the 0–2.6 mile range, and it reflects a more rapid home turnover rate.

The results of the 1989 range show the *Dist* variable to be significant at the 1% level. The positive coefficient sign clearly indicates a direct relationship between house prices and distance from the location of the landfill. In addition, the *Livspc* variable exhibits the correct sign and statistical significance. The *Hbaths* variable is not significant, suggesting the relatively large houses found in this community do not value half baths.

Exhibit 5
Multiple Regression Models for Houses Located between 2.6 to 5.75 Miles from Riga Township Landfill Site Proposal, near the City of Sylvania, Ohio, 1988 and 1989, January through August 1990, Using Three Independent Variables[a]

	Intcpt	*Dist*	*Livspc*	*Hbath*	R^2	*F*-Ratio	Std. Error
Equation 5.1							
1988	−21.036	.664	.624	3.573	.701	239.3	24.8
	(2.61)	(.40)	(23.36)	(1.25)			
Equation 5.2							
1989	−49.684	4.160	.077	.004	.717	431.0	32.0
	(6.11)	(2.53)	(31.53)	(.001)			
Equation 5.3							
1990	−49.586	4.640	.070	15.345	.647	81.8	39.6
	(2.47)	(1.19)	(12.93)	(2.16)			

[a]*T*-scores are in parentheses in absolute values.

However, the same regression model was computed substituting *Full* baths for half baths, and the *Full* bath variable was highly significant.

The findings show the real estate market tends to react to bad news quickly and decisively. Moreover, it appears to be efficient in the same context as the securities markets, but the time frame for the adjustment process tends to be longer reflecting the relatively lower liquidity of residential real estate. This finding substantiates the contention that the mere announcement of bad news affecting the status of real estate such as the establishment of a potentially dangerous waste landfill adversely affects housing prices in the proximity to the site. What is surprising, however, is the large distance outward from the site in which reaction is negative to the news. Whether it was the type of the waste destined for the landfill—radioactive—or simply its mere existence nearby, it is not possible to determine from the data. Nevertheless, no longer can we assume that merely planning a landfill for a given location will have no significant impact on the neighborhoods beyond sight of the plan. Although not given in the data, the aggregate cost in lost property values and tax revenues can be sizable over time.

The regression results for 1990, for the 2.6–5.75 mile range, show the *Dist* variable reverting back to statistical nonsignificance, as in the pre-announcement period of 1988. This finding affirms the belief that once the public became convinced that either the landfill would not soon materialize, or the threat of the landfill would be removed, the market would quickly rebound to its prior valuation processes. As with Envirosafe, the distance range "greater than 5.75 miles," none of the *Dist* variables in the regression models were significant. Consequentially, these findings are not reported in the text.

Conclusions

The results of this research study clearly demonstrate an adverse economic impact on the values of residential housing located in proximity to a toxic or radioactive landfill. Most notable of the findings is the considerable distance outward from the site of the landfill affected, in excess of 2.6 miles, and up to 5.75 miles. In addition, the rapidity of excess market adjustment to the announcement of the Riga Township low-level radioactive landfill, and its subsequent withdrawal, provided sharp evidence of local real estate market efficiency. Consequently, research hypothesis 1 was rejected. Hypotheses 2, 3, and 4 were partially rejected, in that real estate sales prices were adversely affected in the 0–2.6 mile range for the Envirosafe Landfill for each of the five years in the study. For sales occurring beyond the 2.6 mile radius, housing values were not adversely affected. In this distance range, house sale prices were devalued with each incremental mile from $9,000 to as much as $14,000 in a particular year.

The newly proposed Riga Landfill for low-level nuclear waste demonstrated a more pronounced price effect. The distance effect continued outward from the site to 5.75 miles. Statistical significance of the distance variable was first observed in 1989 data, the year in which the nuclear waste facility site was announced. The distance variable became nonsignificant in 1990, once it was apparent the authorities would withdraw the proposal for the facility in Riga Township. The local real estate market was clearly responsive to bad news announcements, but demonstrated an ability to recover quickly once the perceived threat was removed.

The implications of these findings to individuals, businesses, and agencies involved

with real estate transactions are important. Aside from the practical realities of toxic leakage occurring to the surrounding environment, the location of a landfill of toxic chemicals or nuclear waste carries with it costs exceeding the mere acquisition cost of site land used to store hazardous wastes. The results demonstrate clearly that the adverse economic impact extends outward well beyond the actual disposal site, i.e., the economic costs are borne by surrounding real estate owners. Whether or not the technology of the landfill design and its operation is reliable, the results show a considerable skepticism among those choosing neighborhoods for their residences if a hazardous waste landfill is in the area. The study found distance coefficients much larger and more significant than most prior research studies, largely because of the toxic nature of the landfills used in this study.

Notes

[1]The two sites are approximately 20 miles apart in linear distance.

[2]R^2 is used here as a model selection criterion.

[3]Kohlhase used this methodology in her work to establish uniform concentric circles outward from the landfills. The distance separating the concentric circle boundaries captures those houses that are affected approximately equally by their proximity to the landfill.

[4]Discussion of the tests of the research hypotheses is presented in the Conclusions.

[5]The reader will note in the following exhibits the coefficients change from the values found in Exhibits 1 and 2. The differing coefficients are caused by two elements. First, the causal relationship is being measured statistically in the actual data. The second cause for changing values is attributable to errors in specification of the model, or "lack of fit" of the regression model.

[6]The statistical means for the respective variables used in the analysis can be useful to provide perspective on the interpretation of the data. The following means are for 1989, the most recent year with twelve months of data, in the 0–2.6 mile range.

	Riga Landfill	Envirosafe Landfill
Saleamt ($000)	124.191	57.138
Distance	2.103	1.663
Half baths	.900	.276
Living space	1,997.034	1,309.704
Full baths	1.761	1.174

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