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The Impact of Hazardous Materials on Property Value

Public opposition to the handling, storage, or disposal of hazardous materials in proximity to human or wildlife populations is high. How to safely deal with such hazardous materials is thus becoming a significant national issue. The impact of hazardous materials on property value is difficult to measure, however. While some models of real and perceived risk exist, to integrate them with actual market behavior is problematic. A theory of how contamination influences value that incorporates the damage related to lost income as well as the damages incurred by the lost opportunity to fully use a property is presented in this article. In addition, the effects of both the uncertainty concerning a particular hazard and the persistence of a perceived risk over time and distance are considered.

The issue of the safe handling, storage, and disposal of hazardous and toxic materials is becoming a significant national problem. On an economic basis alone, the known environmental risk to real estate from hazardous and toxic materials is estimated to be $2 trillion.[1]

Community opposition to the handling, storage, or disposal of wastes in proximity to human or wildlife populations is high, and the "not in my backyard" syndrome is widespread. One reason for this high level of concern is the fear of a negative impact on property value. This is especially true if a property is in proximity to a generating, handling, disposal, or storage site. This fear relates to both real and perceived health risks.

While models of real and perceived risk exist, they lack empirical content and applicability to real estate. These models are thus difficult to integrate with actual market behavior. Further, the effects of hazardous and toxic materials on a wide range of independent variables (e.g., actual costs to monitor risk and to clean up wastes, or soft costs such as a stigma that ad-

1. *Focus*, September 1990.

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versely affects the financing of property) are unknown. Clearly, however, market behavior does influence real property value.

THE PUBLIC'S RESPONSE TO CONTAMINATION

Research reveals that approximately two decades ago, the general public was not overly concerned about the presence of hazardous and toxic materials or the health risks these materials posed. In two surveys two years apart, Louis Harris documented that in the late 1970s the focus of concern about nuclear power facilities changed dramatically. While previously people had been concerned about a catastrophic accident, by 1980 people were principally concerned with the storage of hazardous waste.[2] Rankin[3] and Forcade[4] have also used survey research techniques to document how concern about hazardous and toxic materials has been changing over time. It thus can be seen that the public response to contamination has a time dimension.

The response to hazardous materials also is affected by a distance dimension. Webb[5] conducted interviews with residents who lived at varying distances from a nuclear power plant and found that the perceived impact of a power plant on property values lessened significantly as the distance from the power plant increased. Clearly, perceptions of hazards are changing over time and depend on distance from the source of the hazard.

REAL ESTATE VALUE IMPACT CAUSED BY CONTAMINATION

A significant amount of research has been done in an attempt to quantify the effects of various types of contamination on property value. While such statistical models as hedonic price models, multiple regression, and PROBIT have been used in this research and such contamination sources as nuclear power plants, sanitary landfills, and air pollution have been studied, the results have been inconclusive.

Six studies have used multiple regression in their analyses. Both Ziess[6] and Havlicek,[7] for example, studied the effect sanitary landfills have on property values. Ziess's research indicates that in six cases property value decreased, in eight no significant change occurred, and that value increased in one case, while Havlicek's research also found that property value impact varied according to distance from and degrees away from a downwind line from the site. However, Rudzitis[8] reanalyzed Havlicek's data, brought in new data, and concluded that such factors had no

2. Louis Harris, *Public Opinion* (April/May 1980): 26.
3. William L. Rankin and Barbara D. Melber, *Public Perceptions of Nuclear Waste Management Issues* (Seattle, Washington: Battelle Memorial Institute Human Affairs Research Centers, 1980).
4. Bill S. Forcade, "Public Participation in Siting," *Hazardous Waste Management in Whose Backyard?*, M. Hearthill, ed. (Colorado: Westview Press, 1984).
5. James R. Webb, "Nuclear Power Plants: Effects on Property Values," *The Appraisal Journal* (April 1980): 230–235.
6. Chris Ziess and James Atwater, "Waste Facility Impacts on Residential Property Values," *Journal of Urban Planning and Development* v. 115 (1989): 123–134.
7. Joseph Havlicek, Jr., Robert Richardson, and Lloyd Davies, "Measuring the Impacts of Solid Waste Disposal Site Location on Property Values," *University of Chicago Urban Economics Report No. 65* (November 1971; unpublished c. 1972).
8. G. Rudzitis and E.G. Hwang, "The External Costs of Sanitary Landfills," *Journal of Environmental Systems* v. 7, no. 4 (1977–1978): 301–308.

effect of any consequence on property value. In addition, Gamble[9] studied ten landfill sites and found no value effect.

The impact that nuclear power plants have on property value has been researched by both Gamble[10] and Nelson.[11] Gamble analyzed 540 single-family residential sales near four nuclear power plants and found no effect, while Nelson obtained the same result from studies of sales and listings in the vicinity of Three Mile Island. Blomquist,[12] however, found that proximity to a power plant did have an effect on property values and Egar[13] found a moderate relationship between the amount of air pollution and changes in property value.

Other researchers have used different research techniques with results that are just as confusing. For example, McClelland[14] used ordinary least squares and PROBIT in the analysis of 178 real estate transactions and found a significant correlation between selling price and neighborhood risk associated with hazardous waste sites. On the other hand, Greenberg found that "Property value and rent in 189 dump site communities appreciated more than those of the remainder of their counties."[15] Hageman[16] used a hedonic price model based on survey research to study nuclear power plants and found little effect. He predicted, however, that with the public becoming more sensitive to incidents and litigation, property value may be affected to a larger extent in the future.

Interesting research has been conducted to discover ways to allay people's concerns about property value impacts. One way is to guarantee residents that the value of their property will not decrease. In interviewing 117 households, Ziess[17] found that people would not accept guarantees. To determine whether residents were willing to allow a hazardous waste site in "their backyard," Kunreuther[18] conducted both a national and statewide survey (in Nevada) and found that if assured that the hazardous waste site was safe, residents would accept compensation and agree to allow the site to be located near them. Smith[19] surveyed 609 households in an at-

9. Hays B. Gamble, R.H. Downing, J.S. Shortle, and D.J. Epp, "Effects of Solid Waste Disposal Sites on Community Development and Residential Property Values," *Final Report for Bureau of Solid Waste Management*, Dept. of Environmental Resources, Commonwealth of Pennsylvania (Institute for Research on Land and Water Resources, Pennsylvania State University, November 1982).

10. Hays B. Gamble and Roger H. Downing, "Effects of Nuclear Power Plants on Residential Property Values," *Journal of Regional Science*, v. 22, no. 4 (1982).

11. Jon P. Nelson, "Three-Mile Island and Residential Property Values: Empirical Analysis and Policy Implications," *Land Economics* (August 1981): 363–372.

12. Glenn Blomquist, "The Effect of Electrical Utility Power Plant Location on Area Property Value," *Land Economics* (February 1974): 97–100.

13. Francis J. Egar, "Air Pollution and Property Values in the Hartford Metropolitan Region," unpublished PhD dissertation, Fordham University (1973).

14. Gary H. McClelland, William D. Schulze, and Brian Jurd, "The Effect of Risk Beliefs on Property Values: A Case Study of a Hazardous Waste Site," *Risk Analysis*, in press.

15. Michael R. Greenberg and Richard F. Anderson, *Hazardous Waste Sites: The Credibility Gap* (New Bruswick, NJ: Center for Urban Policy Research, 1984).

16. Ronda K. Hageman, "Nuclear Waste Disposal: Potential Property Impacts," *Natural Resources Journal* (October 1982): 789–810.

17. Zeiss and Atwater, 123–134.

18. Howard Kunreuther, William H. Desvousges, and Paul Slovic, "Nevada's Predicament," *Environment* (October 1988): 16–33.

19. V. Kerry Smith and W. H. Desvousges, "An Empirical Analysis of the Economic Value of Risk Changes," *Journal of Political Economy* v. 95, no. 11 (1987).

When the contamination is controlled, the value of the property would be expected to increase to full market value if the public believes scientists and public health experts. Whether this actually occurs is debatable, however, because the public does not necessarily agree with the scientific community.

tempt to determine whether people were willing to pay to decrease risk. His study was not directly related to real estate value, however, and the results of his research were inconclusive.

These researchers used many statistical techniques to determine whether risk associated with various types of hazardous and toxic material has an impact on property value. A review of this research leads to several conclusions. First, an adequate general theory of how contamination affects property value has not been developed. A link has not been established between a general theoretical model and a site-specific empirical model. Second, property values are affected by many complex events over time. While both the severity and the persistence of contamination have an effect, these factors are not necessarily related. Third, the statistical models have not been properly used. Data sets are too small, and the variables are neither properly specified nor adequate. That is, they do not reflect important moderating variables, such as lender/lending institution attitudes, which have substantial effects on the marketability and value of property.

HOW CONTAMINATION INFLUENCES PROPERTY VALUE: A THEORY

The impact a contaminating material has on the value of a property can be traced on a time continuum. Initially, a clean property has a value equal to full market value. In many cases a dirty (i.e., contaminated) property that is perceived as clean can also have a value equal to full market value. When the public, or an influential part of it (e.g., a scientist, the media) becomes aware that a contaminated property poses a health or financial risk (either real or perceived), the property is transformed into a problem property, which will affect value.

When the market[20] perceives a property as a problem, value will be significantly affected in several ways. A disclosure requirement by the sales agent or seller, concern on the part of the lender, and appraiser uncertainty all may have a noticeable effect on the marketability of the property. When a property loses its marketability, it also loses its value. Considerable uncertainty may occur at this stage as people involved in the transaction attempt to understand the magnitude of the problem.

When the problem is understood, uncertainty is lessened and the value of a property should then increase to a point at which the difference between its contaminated value and its market value is the sum of the cost to control[21] the problem plus any residual stigma. When the contamination is controlled, the value of the property would be expected to increase to full market value if the public believes scientists and public health experts.

Whether this actually occurs is debatable, however, because the public does not necessarily agree with the scientific community. This difference between cured value and full market value is the residual uncertainty caused by stigma, and should decrease with time as the

20. The market is broadly defined as the various actors who are involved in a real estate transaction, such as the buyer, seller, real estate agent, appraiser, lender, title insurer, soils engineer, and so on.

21. The appraisal literature typically refers to this as the cost to cure. However, as Al Wilson, president of Environmental Assessment and Valuation, appropriately points out, we seldom know if the contamination problem is completely cured. (Appraisal Institute Symposium, Philadelphia, October 3 and 4, 1991.)

public's perception of risk subsides—assuming there is no further contamination.

The factor of persistence concerns the time between the onset of a problem and the decrease in stigma to the point at which full market value is again reached. The length of time is a function of the severity of the problem and varies with the type and amount of contamination, time to cure as well as how the cure is accomplished, media exposure, real and perceived health risk, and visibility, among other things.

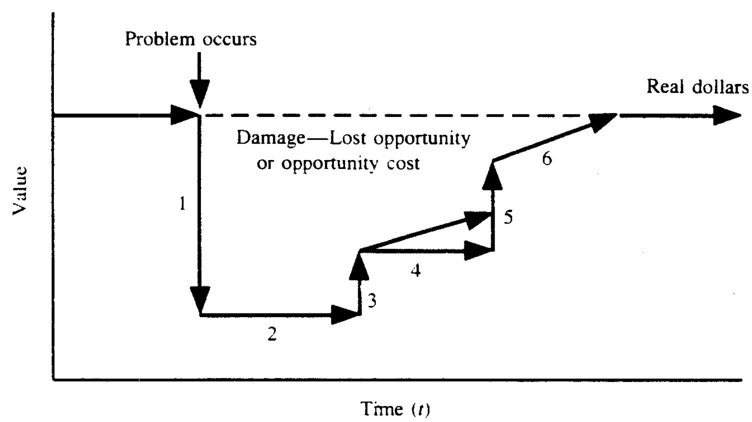
For an income-producing property such as an apartment, this process has two value-influencing components. The first is the impact the hazard has on the marketability of a property. This process is illustrated in Figure 1. The second is the effect the hazard has on the property's income-producing ability, which is shown in Figure 2. For non-income-producing property the income effect would be the lost utility of the property.[22] Because contaminants affect both income and marketability, it is necessary to measure each separately.

Income effect

This is the present value of the difference between the property value as if uncontaminated and the property value as if contaminated, and is related to lost income. The damage is estimated by discounting the present value of lost income over the duration of an event—at a market interest rate in the uncontaminated condition, and at a risk rate in the contaminated condition.

$$\text{Damage} = V_C - V_D$$

FIGURE 1 Marketability Effect

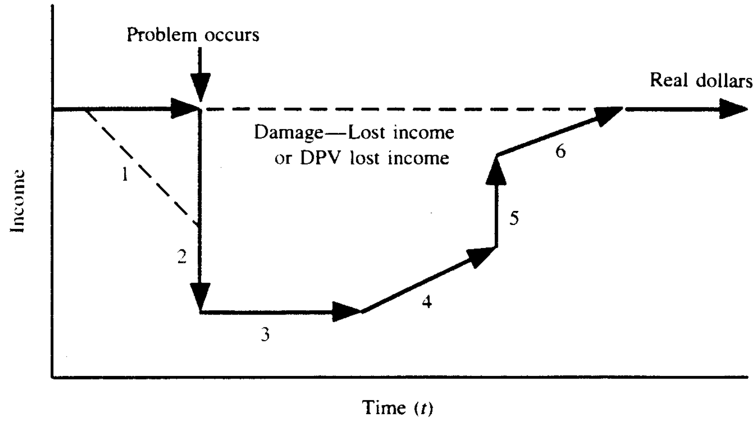


1 = Loss in value as a result of diminished marketability. Public becomes aware of the problem. How buyers and intermediaries perceive risk (unknown & dread factors).
2 = Duration. Time to understand relationship between hazard and risk.
3 = Amount of improvement in value resulting from knowledge (scientific) of hazard and effect knowledge has on perceived risk.
4 = Duration as hazard remains. Value may change as perceived risk changes.
5 = Increased value caused by removal of hazard (i.e., cost to cure).
6 = Stigma remaining after hazard removed. A period of uncertainty related to uncontrollable, involuntary, unknown, unobservable character of the hazard.

Damage—Related to opportunity. Lost opportunity is an opportunity cost measured by the diminished value over the duration of the event at a market rate.

22. The multivariate technique conjoint measurement may offer promise in quantifying, in dollar terms, the lost utility.

FIGURE 2 Income Effect



1 = Possible decrease in income if hazard observable, known.
2 = Decreased income when problem becomes publicly known: Perceived risk becomes a major factor affecting rent, occupancy, expenses.
3 = Duration: Time the hazard remains.
4 = Improved income as people become accustomed to the hazard.
5 = Improved income caused by removal of hazard.
6 = Stigma.

Damage—Related to lost income. Estimated by discounting present value of lost income over duration of event at market interest rate, in the uncontaminated condition, at a risk rate in the contaminated condition.

where

V_C = Value clean
V_D = Value dirty

$$V_C = \sum_{t=1}^{n} \frac{NOI_C}{(1 + {}^{i}m)^t} + \frac{NOI_C}{(1 + {}^{i}m)^n}$$

where

NOI_C = Net operating income (clean)
${}^{i}m$ = Market rate

$$V_D = \sum_{t=1}^{n} \frac{NOI_D}{(1 + {}^{i}r)^t} + \frac{NOI_D}{(1 + {}^{i}r)^n}$$

where

NOI_D = Net operating income (dirty)
${}^{i}r$ = Risk rate as a result of contamination

Marketability effect

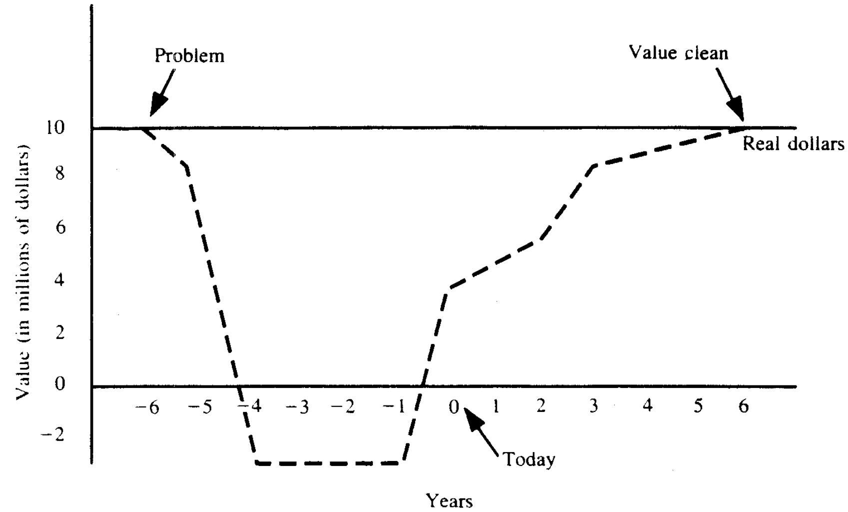
This part of the analysis quantifies the damage directly related to the lost opportunity to fully use the affected property. The situation is analogous to that which occurs when an owner of a frozen asset, while able to enjoy the income the asset generates (although the income may be less than expected), cannot sell the asset or use it for collateral. In such a case, an asset can actually become a liability, thus encumbering other assets.

The damage is related to lost opportunity, and this cost is measured by the present value of the diminished value over the duration of the event at a market rate.[23]

Figure 1 can be expanded to clarify the marketability impact. Figure 3 shows, on a year-by-year basis, how the value for real estate may be influenced by contamination. The damage may be quantified as follows.

23. One needs to be careful when quantifying income and marketability value effects to make sure double counting does not occur. When only income or marketability has been affected, double counting will not be a problem. When both are affected, an analyst must make sure each is quantified independently of the other.

FIGURE 3 Quantifying the Marketability Impact



1 = Loss in value as a result of perceived risk and stigma.
2 = Uncertainty as research on contamination proceeds.
3 = Scope of problem and level of risk becomes known. Scientific risk does not necessarily equal perceived risk.
4 = Cost to cure contamination plus risk (stigma) impact.
5 = Cleanup process.
6 = Residual stigma.

Damage[24]

$$= \left[\sum_{i=1}^{n} PV_{r_r}(V_C - V_D)(r_m) + \sum_{i=1}^{n} PV_{r_r}(\text{cleanup cost})\right] + \left[\sum_{i=0}^{n} FV_{r_r}(V_C - V_D)(r_m) + \sum_{i=0}^{-n} (FV_{r_r})(\text{cleanup cost})\right]$$

where

n = Annual periods
V_C = Value clean
V_D = Value dirty
r_m = Market rate
PV = Present value
r_r = Risk rate
FV = Future value

An example of how such damage could be calculated is shown in Table 1. As an example, assume a non-income-producing property is located near a source of contamination such as a landfill. Contaminated ground water and methane gas have migrated to the subject property, and a cleanup is required. The public became aware of this problem five years ago, when the market value of the property was $21.8 million. Market evidence applied to both the market and income approach reveals that the value of the property has decreased by 55%, or $12 million. Therefore, five years ago there was a value decrease for two-twelfths of the year ($200,000), and the decrease is applied to the entire fourth year ($12 million).

The owner of the property is entitled to a market rate of return on the investment, which might be 10%, or $2,180,000, for the entire property and $1,200,000 for the damaged part. This is the owner's opportunity cost—the cost of hav-

24. The formula on the left side of the plus sign quantifies the historical opportunity costs.

TABLE 1 Calculation of Damage to Marketability

	Year	Loss in Value ($000,000)	Market Rate*	Opportunity Cost ($000,000)	Misc. Cost ($000)	Cleanup Cost ($000)	Risk Rate**	Total Damage (Present Value in $000)
	−6	$ 0.0	10%	$0.00	$ 0	$ 0	15%	$ 0.0
	−5	$ 2.0	10%	$0.20	$ 0	$ 0	15%	$ 402.3
	−4***	$12.0	10%	$1.20	$ 0	$ 0	15%	$2,098.8
	−3	$12.0	10%	$1.20	$ 0	$ 0	15%	$1,825.1
	−2	$12.0	10%	$1.20	$ 0	$ 0	15%	$1,587.0
	−1	$12.0	10%	$1.20	$ 4.0	$ 0	15%	$1,384.6
Today	0	$ 7.0	10%	$0.70	$10.0	$ 0	15%	$ 710.0
	+1	$ 6.0	10%	$0.60	$20.0	$100	15%	$ 626.1
	+2	$ 4.0	10%	$0.40	$15.0	$100	15%	$ 389.4
	+3	$ 1.5	10%	$0.15	$ 2.0	$ 20	15%	$ 113.1
	+4	$ 1.0	10%	$0.10	$ 2.0	$ 0	15%	$ 58.3
	+5	$ 0.5	10%	$0.05	$ 1.0	$ 0	15%	$ 25.4
Total damage, marketability								$9,220.1

*Rate as if clean. The normal return one would receive on this class of asset. Equivalent to annual rate from market evidence.
**Rate reflecting added risk caused by known contamination. The rate might be equated to a junk bond rate.
***Includes $2.0 million personal liability.

ing the asset frozen. The $1.2 million opportunity cost occurred four years ago. The present value, using a 15% risk rate (because the property and the property owner are jointly and severally liable for damages) is $402,300. This set of circumstances concerns historical damages.

Currently, the property owner may have completed preliminary site testing and may know the extent of contamination. Because uncertainty is diminished, the loss in property value is diminished. Substantial engineering and testing, legal, and appraisal costs are being incurred, however, which are estimated at $10,000 this year and $20,000 next year. These are shown as miscellaneous costs. Next year (year + 1) cleanup will begin at $100,000. Therefore, in year + 1 costs will be:

Opportunity cost on lost value	$600,000
Miscellaneous costs	$ 20,000
Cleanup costs	$100,000
Total (year + 1)	$720,000

The present value of these costs, discounting at the 15% risk rate, is $626,087, which is rounded to $626,100. In year + 4, these are nominal miscellaneous costs ($2,000), but a lingering stigma effect still has a $1 million impact on the property's value. Over the entire ten-year period the present value of the costs, which includes opportunity and out-of-pocket costs, is $9.22 million, which is a measure of the damage suffered by the property owner as a result of lost marketability. For an income-producing property, the damage would be increased by the present value of the lost *NOI*.[25]

25. For an income-producing property the analysis becomes more complex. Factors that need to be considered include the risk rate (when applied to the income stream), which may account for the lost marketability. Also, debt and collateral will affect the amount the property owner has at risk. The author is presently working on a method to quantify these damages.