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The Impact of Hazardous and Toxic Material on Property Value: Revisited

This article is an extension of an earlier article that appeared in the April 1992 issue of *The Appraisal Journal* on the impact of hazardous material on property value. Two further methods for quantifying the impact of contamination on rent, occupancy, expenses, debt, equity, and capitalization rates are presented and discussed here.

In "The Impact of Hazardous and Toxic Materials on Property Value," I presented a theory about the ways in which contaminants influence property value as well as a method to quantify such influences.[1] The value of property may be affected both by an impact on the income stream and by an impact on its marketability. The income effect (i.e., damage) is measured as follows:

$$\text{Damage} = V_U - V_I$$

$$V_U = \sum_{t=1}^{n} \frac{NOI_U}{(1 + i_m)^t} + \frac{NOI_U}{(1 + i_m)^n} \quad (1)$$

$$V_I = \sum_{t=1}^{n} \frac{NOI_I}{(1 + i_r)^t} + \frac{NOI_I}{(1 + i_r)^n}$$

where

V_U = Value unimpaired
V_I = Value impaired
NOI_U = Net operating income, unimpaired

1. Bill Mundy, "The Impact of Hazardous and Toxic Materials on Property Value," *The Appraisal Journal* (April 1992): 155–162.

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NOI_I = Net operating income, impaired[2]
i_m = Market rate
i_r = Risk rate

The marketability effect, or the loss in the opportunity to use a property as a result of its contaminated condition, is synonymous with the effect of a frozen asset. The marketability effect was measured as follows:[3]

$$\text{Damage} = \left[\sum_{i=1}^{n} PV_{r_r}(V_U - V_I)(r_m) + \sum_{i=1}^{n} PV_{r_r}(\text{cleanup cost})\right] + \left[\sum_{i=0}^{n} FV_{r_r}(V_U - V_I)(r_m) + \sum_{i=0}^{-n} FV_{r_r}(\text{cleanup cost})\right] \quad (2)$$

where

r_r = Risk rate
r_m = Market rate
V_U = Value unimpaired
V_I = Value impaired
PV = Present value
FV = Future value

The opportunity cost is the difference between the value unimpaired and the value impaired of a property if the owner could fully use it; for example, if 100% of its value is used as collateral, and if the risk rate in Equation 1 does not also take into consideration the marketability opportunity cost. This seldom reflects reality, however. Because most real estate is encumbered with debt, an owner does not have the entire value of the property at his or her disposal. Also, such other factors as liens against the property may restrict its use as collateral.

The value of a property, unimpaired, is shown in Figure 1, which represents an income-producing property. For a non–income-producing property—for example, a single-family, owner-occupied residence or vacant land—it would be necessary to estimate an income stream.

Mathematically, the process used to determine the present value of that income stream is as follows:

$$V_U = \sum_{t=1}^{n} I_U(1 + r_m)^n$$

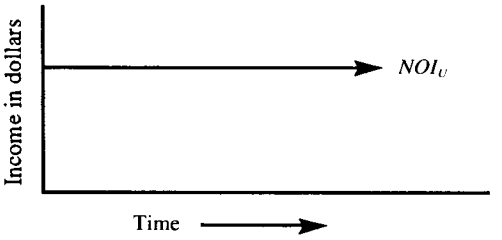
For the impaired property the following factors may influence the income stream and value and therefore the impaired value.

- Factors that affect the net operating income:
  1. A decrease in rent.
  2. A decrease in occupancy.
  3. An increase in operating expenses.
- Factors that affect the rate:
  4. An increase in risk to the equity. For example, the amount and accessibility of the collateral in a property may change as a result of changing levels of risk.
  5. An increased risk to the debtor's position. For example, the monthly debt

2. The prior article referred to an uncontaminated property as clean (NOI_C) and a contaminated property as dirty (NOI_D). Preferable terms are unimpaired and impaired. Thanks to comments by Al Wilson, President, Environmental Assessment and Valuation.

3. This model was discussed at the Appraisal Institute's symposium in Philadelphia, Pennsylvania, on October 3 and 4, 1991. The model was originally presented at the Weimer School for Advanced Study in Real Estate and Land Economics in January 1991 and subsequently in January 1992. This model is an outgrowth of these presentations. Jeffrey Fisher, PhD, Indiana University, was particularly helpful in reformulating the model. In addition, the author would like to thank the insights and challenge presented by Max Derbes, III, MAI, New Orleans. The author is a fellow at the Weimer School.

FIGURE 1 Property Income Stream—Unimpaired



service or annual debt service may change if the property must be refinanced during that part of the holding period in which contamination is present.

The increases in risk both to the equity and debt can be accounted for in the discount rate for the contaminated property. The rate would reflect all forms of risk to the property, including the opportunity cost from the impaired collateral. Figure 2 represents the income stream for the contaminated property.

The following formula can be used to calculate the value of the property.

$$V_I = \sum_{t=1}^{n} I_I(1 + r_r)^n$$

where

I_I = Income impaired

The damage is therefore the difference between the value unimpaired and the value impaired, or

$$D = V_U - V_I$$

The difficult task for appraisers is to quantify the changes in rent, occupancy, expenses, risk to the equity, and risk to the debt. One method for quantifying the impact on those variables is explained in the following section. Table 1 shows the income, vacancy, expense characteristics, and present value of a hypothetical unimpaired property whose value is $21.9 million.

Changes in rent

The change in rent might be quantified by comparing an impaired property to similar replica properties that do not have the impairment. In addition, it may be possible to track the rent of the impaired property with control properties before, during, and after the contamination problem occurs.

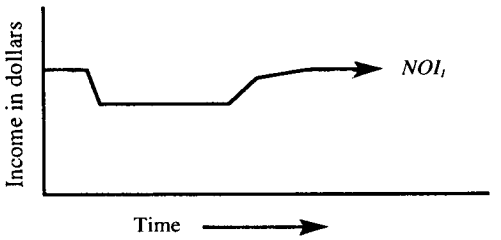
Changes in occupancy

For changes in occupancy, a method similar to that discussed for changes in rent could be followed.

Changes in expenses

Careful interviews should be conducted with the subject property owner to learn how the subject property's expenses have changed. In addition, this should be verified

FIGURE 2 Property Income Stream—Impaired



For an impaired property, the task is to determine an appropriate rate that reflects the risk associated with the particular level of contamination.

if possible with other properties that have also been impaired as a result of contamination. Repair and maintenance expense, professional fees (e.g., attorneys, environmental engineers), and insurance costs may change if there are risks to those who use the property.

Rate

In Table 1, a market rate of 10% was used to determine the discounted present value of the unimpaired property. For an impaired property, the task is to determine an appropriate rate that reflects the risk associated with the particular level of contamination. It is difficult to obtain data to determine the appropriate rate to use in an impaired analysis. Sales of income-producing contaminated property, interviews with investors, or some type of analog can be used to generate data.

In this case, the differential between rates of return on corporate AAA bonds and junk bonds is used—a differential of approximately 500 basis points. For prior years, the 500 basis points are deducted from the market rate and for future years a premium is added for discounting purposes. The process is shown in Table 2. The variables that change are rent and vacancy, with expenses associated with an impairment such as professional fees and cleanup costs also accounted for. In this example, the damage caused by the contamination is estimated at $7 million (value unimpaired of $21.9 million less value impaired of $14.9 million).

Because of the difficulty in obtaining direct and reliable rate data, it is recommended that analysts use multiple methods as a part of the income approach.

Equity

An appraiser could attempt to determine whether, for income-producing properties that have been sold, there was a change in the equity yield rate. This may seem like looking for a needle in the haystack, and probably would be as difficult.

A second method is to conduct interviews in a well-controlled environment with investors in properties similar to the subjects, while a third method is to quantify the change in collateral available as a result of the increased risk. The latter method can be used as a validation tool or as an independent method in itself, but also has its drawbacks in terms of easily obtained, reliable data. The following process can be used.

1. Estimate the unimpaired value.
2. Estimate the impaired value using a market rate (r_m) rather than a risk rate (r_r). This will account for changes in income, occupancy, and expenses as shown in Table 3. In this case the change in value is $4.5 million, which excludes risk to the equity and debt.
3. Estimate the impact on the equity interest. This will account for the impairment or lost opportunity to take advantage of one's equity in the property.
4. Estimate the impact on the debt position in the property.

Debt

For many properties debt will not be affected. If it is necessary to refinance the impaired property during the period of impairment, however, there can be significant risk. For example, it may not be possible to refinance the property, or if the property can be refinanced the terms and conditions under which it will be financed may reflect the increased level of risk to

TABLE 1 Property Value: Unimpaired

	Year	Gross Income	Vacancy at 5%	Effective Gross Income	Expense Ratio 30%	Net Operating Income	Market Rate (i_m)	Present Value
	−6	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 2,915,768
	−5	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 2,650,698
	−4	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 2,409,726
	−3	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 2,190,660
	−2	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 1,991,509
	−1	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 1,810,463
Today	0	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 1,645,875
	1	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 1,496,250
	2	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 1,360,227
	3	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 1,236,570
	4	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 1,124,155
	5	$2,475,000	$123,750	$2,351,250	$705,375	$1,645,875	10%	$ 1,021,959
						Total value		$21,853,859
						Rounded to		$21,900,000

TABLE 2 Property Value: Impaired (present value based on risk rate)

	Year	Gross Income	Vacancy Rate	Vacancy	Effective Gross Income	Expense Ratio at 30%	Costs Resulting from Impairment: Professional Fees	Costs Resulting from Impairment: Clean-up	Net Operating Income	Risk Rate (i_r)	Present Value
	−6	$2,475,000	5%	$123,750	$2,351,250	$705,375			$1,645,875	5%	$ 2,205,630
	−5	$2,351,250	10%	$235,125	$2,116,125	$634,838			$1,481,288	5%	$ 1,890,540
	−4	$2,227,500	15%	$334,125	$1,893,375	$568,013			$1,325,363	5%	$ 1,610,986
	−3	$1,980,000	20%	$396,000	$1,584,000	$475,200			$1,108,800	5%	$ 1,283,575
	−2	$1,732,500	25%	$433,125	$1,299,375	$389,813			$ 909,563	5%	$ 1,002,793
	−1	$1,856,250	20%	$371,250	$1,485,000	$445,500	$ 4,000		$1,035,500	5%	$ 1,087,275
Today	0	$1,980,000	15%	$297,000	$1,683,000	$504,900	$10,000		$1,168,100	15%	$ 1,168,100
	1	$2,103,750	10%	$210,375	$1,893,375	$568,013	$20,000	$100,000	$1,205,363	15%	$ 1,048,141
	2	$2,227,500	10%	$222,750	$2,004,750	$601,425	$15,000	$100,000	$1,288,325	15%	$ 974,159
	3	$2,351,250	10%	$235,125	$2,116,125	$634,838	$ 2,000	$ 20,000	$1,459,288	15%	$ 959,505
	4	$2,475,000	10%	$247,500	$2,227,500	$668,250	$ 2,000		$1,557,250	15%	$ 890,363
	5	$2,475,000	10%	$247,500	$2,227,500	$668,250	$ 1,000		$1,558,250	15%	$ 774,726
									Total value		$14,895,792
									Rounded to		$14,900,000

TABLE 3 Property Value: Impaired (present value based on market rate)

	Year	Gross Income	Vacancy Rate	Vacancy	Effective Gross Income	Expense Ratio at 30%	Costs Resulting from Impairment		Net Operating Income	Risk Rate (i_r)	Present Value
							Professional Fees	Clean-up			
	−6	$2,475,000	5%	$123,750	$2,351,250	$705,375			$1,645,875	10%	$ 2,915,768
	−5	$2,351,250	10%	$235,125	$2,116,125	$634,838			$1,481,288	10%	$ 2,385,628
	−4	$2,227,500	15%	$334,125	$1,893,375	$568,013			$1,325,363	10%	$ 1,940,463
	−3	$1,980,000	20%	$396,000	$1,584,000	$475,200			$1,108,800	10%	$ 1,475,813
	−2	$1,732,500	25%	$433,125	$1,299,375	$389,813			$ 909,563	10%	$ 1,100,571
	−1	$1,856,250	20%	$371,250	$1,485,000	$445,500	$ 4,000		$1,035,500	10%	$ 1,139,050
Today	0	$1,980,000	15%	$297,000	$1,683,000	$504,900	$10,000		$1,168,100	10%	$ 1,168,100
	1	$2,103,750	10%	$210,375	$1,893,375	$568,013	$20,000	$100,000	$1,205,363	10%	$ 1,095,784
	2	$2,227,500	10%	$222,750	$2,004,750	$601,425	$15,000	$100,000	$1,288,325	10%	$ 1,064,731
	3	$2,351,250	10%	$235,125	$2,116,125	$634,838	$ 2,000	$ 20,000	$1,459,288	10%	$ 1,096,384
	4	$2,475,000	10%	$247,500	$2,227,500	$668,250	$ 2,000		$1,557,250	10%	$ 1,063,623
	5	$2,475,000	10%	$247,500	$2,227,500	$668,250	$ 1,000		$1,558,250	10%	$ 967,551
									Total value		$17,413,466
									Rounded to		$17,400,000

TABLE 4 Opportunity Cost of Impaired Collateral

	Year	Value Unimpaired* *Vu*	Value Impaired* *Vi*	Value Change* *Vchg*	Value of the Debt* *Vd*	Value of the Equity* *Ve*	Loan-to-Value Ratio *L/V*
	−6	$16,459	$10,973	$ 5,486	$9,875	$6,584	75%
	−5	$16,459	$ 9,875	$ 6,584	$9,875	$6,584	75%
	−4	$16,459	$ 8,836	$ 7,623	$9,875	$6,584	75%
	−3	$16,459	$ 7,392	$ 9,067	$9,875	$6,584	75%
	−2	$16,459	$ 6,064	$10,395	$9,875	$6,584	75%
	−1	$16,459	$ 6,903	$ 9,555	$9,875	$6,584	75%
Today	0	$16,459	$ 7,787	$ 8,671	$9,875	$6,584	75%
	1	$16,459	$ 8,036	$ 8,423	$9,875	$6,584	75%
	2	$16,459	$ 8,589	$ 7,870	$9,875	$6,584	75%
	3	$16,459	$ 9,729	$ 6,730	$9,875	$6,584	75%
	4	$16,459	$10,382	$ 6,077	$9,875	$6,584	75%
	5	$16,459	$10,388	$ 6,070	$9,875	$6,584	75%

* In thousands

** Assumes the equity owner can earn 5% net on borrowed capital

*** For simplicity a nonamortizing loan is assumed. Debt assumptions are as follows:

	Unimpaired	Impaired
Interest rate	10.0%	12.5%
Term in years	30	15
Constant	0.1061	0.1508
Debt service ($000)	$1,047.7	$1,489.1

the lender. This could affect the loan amount, term call provisions, and rate.

An example that shows the impact on value resulting from a change in equity and debt service is presented in Table 4. The impact on the equity and debt position (i.e., opportunity cost) is $2.5 million. This, added to the impact on the income stream ($4.5 million), is a second estimate of the damage, or $7 million.

CONCLUSION

The impact of contamination can have an influence on both the income-generating ability of a property and the level of risk associated with the asset itself. As indicated, rents may decrease, occupancy may decrease, and expenses may increase. Because these changes may take place over time, to quantify the impact of the contamination an analyst can discount the *NOI* to a present value, taking into consideration the unimpaired and impaired nature of the income stream.

The rate at which the income stream is discounted may be a market rate or a risk rate. If it is a risk rate, the implication is that the effect on the equity and debt is accounted for by the rate differential (i.e., difference between the market rate as if unimpaired and the risk rate under the impaired condition).

Alternatively, the impact on the level of risk associated with an asset, and consequently its marketability, can be estimated by determining the change in the equity yield rate over the holding period. This is also true with regard to the change in the debt constant. The former reflects the opportunity cost incurred as a result of the inability to use the collateral in the property.

Value of the Collateral* $Vc = Ve*L/V$	Ratio of Collateral to Value Vc/Vu	Lost Collateral* (LC) $Vchg*Vc/Vu$	Rate Differential**	Return on Lost Collateral*	Change in Debt Service***	Present Value of Opportunity Cost*
$4,938	30%	$1,646	5%	$ 82		$ 110
$4,938	30%	$1,975	5%	$ 99		$ 126
$4,938	30%	$2,287	5%	$114		$ 139
$4,938	30%	$2,720	5%	$136		$ 157
$4,938	30%	$3,119	5%	$156		$ 172
$4,938	30%	$2,867	5%	$143		$ 151
$4,938	30%	$2,602	5%	$130		$ 130
$4,938	30%	$2,527	5%	$126		$ 120
$4,938	30%	$2,361	5%	$118		$ 107
$4,938	30%	$2,019	5%	$101	$441	$ 468
$4,938	30%	$1,823	5%	$ 91	$441	$ 438
$4,938	30%	$1,821	5%	$ 91	$441	$ 417
				Total value		$2,536
				Rounded to		$2,500