# ADVERSE AND BENEFICIAL EFFECTS OF HIGHWAYS ON RESIDENTIAL PROPERTY VALUES

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Four residential communities bisected by Interstate highways were examined to determine the effects of regional accessibility and highway-generated disturbances on property values. Disturbances measured within each community included noise, carbon monoxide, nitrogen dioxide, hydrocarbons, and particulates. Data on traffic mix, volume, and speed were obtained simultaneously. Residents were interviewed to determine their perceptions of highway disturbance and other pertinent information. Data were gathered on all valid property sales from 1969 to 1971. Noise pollution level (NPL) contour lines and CO isopleths were plotted for each community. The NPL regression coefficient was significant in explaining variation in property values in all communities and showed an average loss of $2,050 per property abutting the highway. Based on the high degree of multicollinearity between the NPL and CO variables in the regression model, the NPL coefficient reflects more than just noise-induced property value losses. The relationship among NPL, distance from the highway, and property value loss was determined. There was a high degree of correlation between measured noise (NPL) and perceived noise. Residents objected to noise more than any other highway-originating disturbance. Property value increases due to regional accessibility amounted to $5 million in one community, whereas highway-induced property value losses in the same community were $300,000. Total highway-induced property value losses in the four study communities amounted to about $2.3 million or an average of $1,120 per property.

•BEFORE rational decisions and choices can be made regarding highway location and design alternatives or noise and air pollution abatement programs, it is desirable to have as much information as possible about the relevant benefits and costs. Some of the indirect or social benefits and costs, however, are particularly difficult to measure or estimate. Nevertheless, legislation has been passed and regulations adopted to control vehicular emissions and noise, but the resulting benefits and costs to society have not been adequately considered, primarily because so little is known about them. Benefits to society from pollution abatement programs, whether achieved through highway location and design or through noise and engine emission controls, are the reductions in the costs resulting from pollution.

Motor vehicles are among the major sources of noise and air pollution in urban areas. It has long been suspected that the noise and air pollution from cars and trucks lowers the values of certain kinds of properties (land uses) abutting or close to major highways, just as the benefits of regional accessibility or locational advantage increase the property values of highway-oriented activities. To the extent, then, that property values reflect these adverse and beneficial effects, we can obtain at least partial estimates of the social or indirect costs and benefits of highways.

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This paper reports the findings of a study sponsored by the Federal Highway Administration. This study was the first to attempt to simultaneously determine the adverse effects of highway-originating disturbances and the beneficial effects from improved regional accessibility on property values in highway communities.

The main objectives of the study were to determine the effect of various highway-generated pollutants on property values, to determine the distance from a highway within which these pollutants are discernible by residents, and to estimate the beneficial influence of regional accessibility on property values.

## STUDY AREAS

Four urban communities were selected for study: Bogota, N. J. (including portions of the towns of Ridgefield Park and Teaneck), along I-80; North Springfield, Va., along I-495 (Capital Beltway); Rosedale, Md., along I-95; and Towson, Md., along I-695 (Baltimore Beltway). Residential development is the predominant land use in all four communities. Bogota is an old community and was fully developed at the time I-80 was constructed. Rosedale and Towson were partially developed at the time of highway construction. North Springfield was in an early stage of development when construction of I-495 began. Table 1 gives descriptions of these areas.

The four areas were selected primarily because (a) residential development was the predominant land use and it was felt that this land use more than any other would most likely reflect the negative influence of highway-generated pollutants on property values; (b) the communities were sufficiently large and extended far enough away from the highways so that an area could be delineated in which no adverse highway effects would be felt (a control zone); and (c) the communities were not close to a major highway interchange where property value gains reflecting the highly beneficial aspects of locational advantage would be apt to mask any possible adverse effects on property values.

## DATA REQUIREMENTS

Within each study area data were gathered in 1971 and 1972 on the quantity and dispersion of highway-generated noise and air pollution; traffic volume, speed, and mix; property values; and household characteristics.

Noise measurements were taken at different locations within each study area and at various times during each day. Four different weekdays were sampled in each of the four study areas. Direct sampling of traffic volume, mix, and speed on the Interstate highway, using hand counters and movie cameras, was done concurrently with the noise sampling. Air pollution data were gathered at various locations within each study area at different times of the day during a 3-day period. Air pollutants measured were carbon monoxide, total hydrocarbons, nitrogen dioxide, and particulates. Two mobile air-monitoring vans were used: One was stationed permanently on any one day at a location downwind and adjacent to the highway; the second van moved to various locations within the community and away from the highway. The permanent van also monitored wind speed and direction, temperature, and humidity.

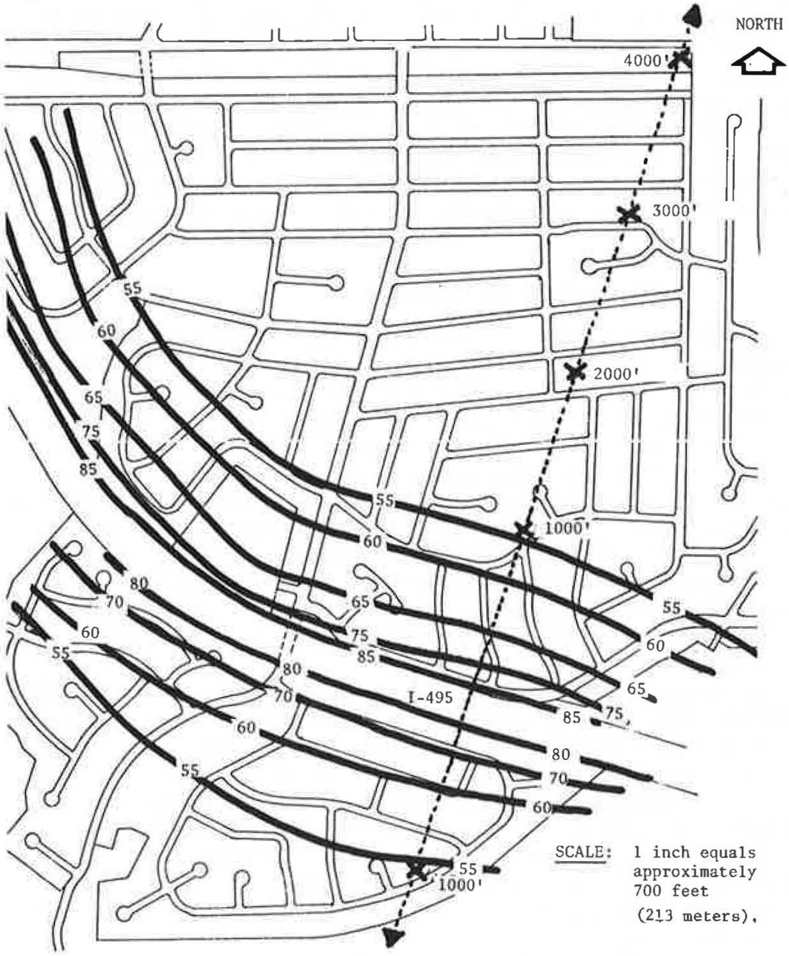
A total of 1,114 households were interviewed in the four communities. A stratified random sampling procedure was used in order to get adequate responses from abutters, nonabutters, and people recently purchasing homes. The questionnaire was designed to elicit information primarily on the attitudes of residents toward pollution from highways plus certain other highway effects on the community, the daily activities of residents around the home, their response to highway effects in terms of home alterations, changes in resident's work and recreation habits, the extent of social interactions in the community, and a number of socioeconomic and demographic variables.

Property value data gathered were the bona fide real estate transactions for 324 residential properties in the four study areas for the years 1969 to 1971 as obtained from public records. In addition, sales data were obtained for 84 residential properties in various locations throughout Fairfax County, Virginia, to determine the positive effects of I-495 on property values resulting from improved regional accessibility.

**Table 1. Selected characteristics of the four study areas.**

| Characteristic | Bogota | Rosedale | Towson | North Springfield |
|---|---|---|---|---|
| Interstate on which located | I-80 | I-95 | I-695 and I-83 | I-495 |
| Year highway opened | 1964 | 1955 | 695-1961; 83-1955 | 1961 |
| Highway directional alignment | E-W | NE-SW | 695-E-W; 83-N-S | NW-SE |
| Number of lanes on Interstate | 10 | 6 | 695-8; 83-4 | 4 |
| 1970 ADT | 69,670 | 54,500 | 73,374 | 65,400 |
| Average percentage of trucks | 18 | 13 | 9 | 9 |
| Zoning and/or other land use regulation (year first adopted) | 1929 | County—1945 | County—1945 | County—1941 |
| Population, 1970 | 27,356 | 9,248 | 7,690 | 17,117 |
| Average value of housing, dollars | 28,400 | 24,800 | 32,600 | 33,300 |
| 1970 median income, dollars | 12,951 | 11,417 | 13,052 | 17,347 |

**Figure 1. NPL contour lines for North Springfield study site.**



The noise pollution level (NPL) developed by Robinson (1) was the objective measure of noise selected for the study. This measure recognizes two sources of annoyance from noise: a steady or nonfluctuating noise and intermittent, short-term fluctuations. Measured on the dBA scale, NPL relates very well to perceived annoyance from noise and provides a higher correlation with human responses to fluctuating noises of various types than do other measures.

A model provided by the National Cooperative Highway Research Program (2, 3) was used in conjunction with the field measurements of noise to estimate noise levels at various distances from the highway in each study area. The model accounted for variations in traffic characteristics (volume, speed, and mix), topography, barriers, vegetation, highway design (elevated or depressed), and roadway characteristics (configuration, pavement type, and grade).

This methodology was used to draw noise contour lines for each study area showing the distance variations in noise level reductions as distance from the highway increased. Figure 1 shows a typical NPL contour line for one of the study areas. The maximum and minimum (ambient) NPLs in the four study areas and the distances from the highways at which the NPL is reduced to ambient are given in Table 2.

An integrated point source model was used to predict CO concentrations in all study areas except Bogota for average traffic volumes and meteorological conditions from 4 to 5 p.m. on weekdays. Isopleths could not be calculated for Bogota because of high background concentrations of air pollutants, which prevented detection of highway-originating pollutants. In the other three study areas the federal CO standard of 9 ppm over an 8-hour average would not be exceeded under normal weather and traffic conditions.

## FINDINGS OF THE STUDY

Because the four communities were not selected at random, the findings cannot be assumed to apply automatically to other highway communities. However, in many respects the study areas are much like many suburban residential communities along major highways near large cities. For this reason, it is expected that the findings may be applicable to many housing developments near major highways.

Analysis of data from the household questionnaire showed that noise is the greatest source of annoyance from the highways to people outdoors. People indoors are annoyed about to the same degree by noise as by dust on windowsills. Odors from the highway are not major sources of annoyance to people indoors or outdoors. Bogota was the only study area in which a disturbance (dust) to people indoors was more strongly stressed than any outdoors disturbance. In all four communities, 58 percent of the abutters were annoyed by highway disturbances, whereas only 12 percent of the non-abutters indicated annoyance.

There was a positive relationship between the degree of annoyance from noise and the extent to which homeowners felt their property values had been adversely affected. People who found the highways convenient for traveling to work, shopping, or socializing were less annoyed by noise, dirt, and odors than infrequent highway users. Residents in these study areas apparently did not grow accustomed to highway noise. The average length of residence was 9 years, and long-time residents reported as much annoyance as newcomers. The degree of annoyance from noise was not associated with income, age, or sex. Blue-collar workers found disturbances from the highway equally as trying as the executive, and there were no significant differences reported between the generations or the sexes.

An important aspect of this phase of the research was to relate people's perceptions of highway disturbances to distance from the highway. Table 3 gives these findings for noise and odors, both indoors and outdoors.

Stepwise multiple regression was the principal statistical tool used to determine the relationship between property values (the dependent variable) and a number of highway-related variables. The model was of the form

$$V = f\,[(H_1,\ H_2, \ldots, H_a),\ (N_1,\ N_2, \ldots, N_6),\ X_1,\ X_2,\ X_3,\ X_4]\ \epsilon$$

**Table 2. NPL and distance from highway at which NPL is reduced to ambient.**

| | NPL (dBA) | | Distance (feet) | |
|---|---|---|---|---|
| Study Area | Maximum | Ambient | Minimum | Maximum |
| Bogota | 80 | 70 | 100 | 600 |
| North Springfield | 85 | 55 | 900 | 1,150 |
| Rosedale | 90 | 60 | 800 | 1,200 |
| Towson | 85 | 55 | 550 | 900 |

Note: 1 foot = 0.3 meter.

**Table 3. Maximum distance from highway within which at least 15 percent of respondents were annoyed by environmental stimuli from Interstate highway.**

| | Distance From Highway (feet) | | | | |
|---|---|---|---|---|---|
| Environmental Stimulus | All Areas | Bogota | North Springfield | Rosedale | Towson |
| Indoors | | | | | |
| Noise | 800 | 400 | 600 | 1,000 | 1,200 |
| Odors[a] | — | — | — | — | — |
| Outdoors | | | | | |
| Noise | 800 | 600 | 800 | 1,000 | 1,000 |
| Odors | 600 | 400 | 600 | — | — |

Note: 1 foot = 0.3 meter.

[a]Less than 15 percent response of annoyance in all areas.

**Table 4. Results of regression analyses.**

| | Bogota | | North Springfield | | Rosedale | | Towson | | All Areas | |
|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Regression Coefficient | Student t | Regression Coefficient | Student t | Regression Coefficient | Student t | Regression Coefficient | Student t | Regression Coefficient | Student t |
| 10 No. of floors | | | 1,201 | 2.04 | | | | | | |
| 11 Age of head | | | | | 94 | 4.04 | | | | |
| 16 Lived near highway | | | | | -853 | 1.73 | | | | |
| 27 No. of rooms | | | 839 | 3.12 | 273 | 1.34 | | | 453 | 2.11 |
| 28 No. of bathrooms | | | 1,578 | 2.16 | 850 | 1.66 | 4,291 | 3.73 | 2,138 | 4.14 |
| 30 Central air conditioning | | | | | | | 2,338 | 1.59 | 1,988 | 3.41 |
| 33 Corner lot | 4,708 | 3.30 | | | | | | | | |
| 50 Rosedale | | | | | | | | | -6,262 | 8.47 |
| 61 Wood-brick-asph.-asb. | | | | | 2,923 | 5.50 | | | | |
| 63 Split-level | | | | | 3,056 | 4.39 | | | | |
| 64 Ranch | | | | | 1,629 | 2.47 | | | | |
| 74 Finished basement | | | 1,807 | 1.94 | | | | | 2,298 | 4.10 |
| 94 NPL-NCHRP | -646 | 2.24 | -69 | 1.42 | -60 | 1.25 | -141 | 2.28 | -82 | 2.37 |
| 96 Age of house | -168 | 4.38 | -569 | 3.88 | | | -385 | 1.74 | | |

Note: Where there are no regression coefficients, the variable was not significant at the 10 percent level.

**Table 5. Data used in regression analyses.**

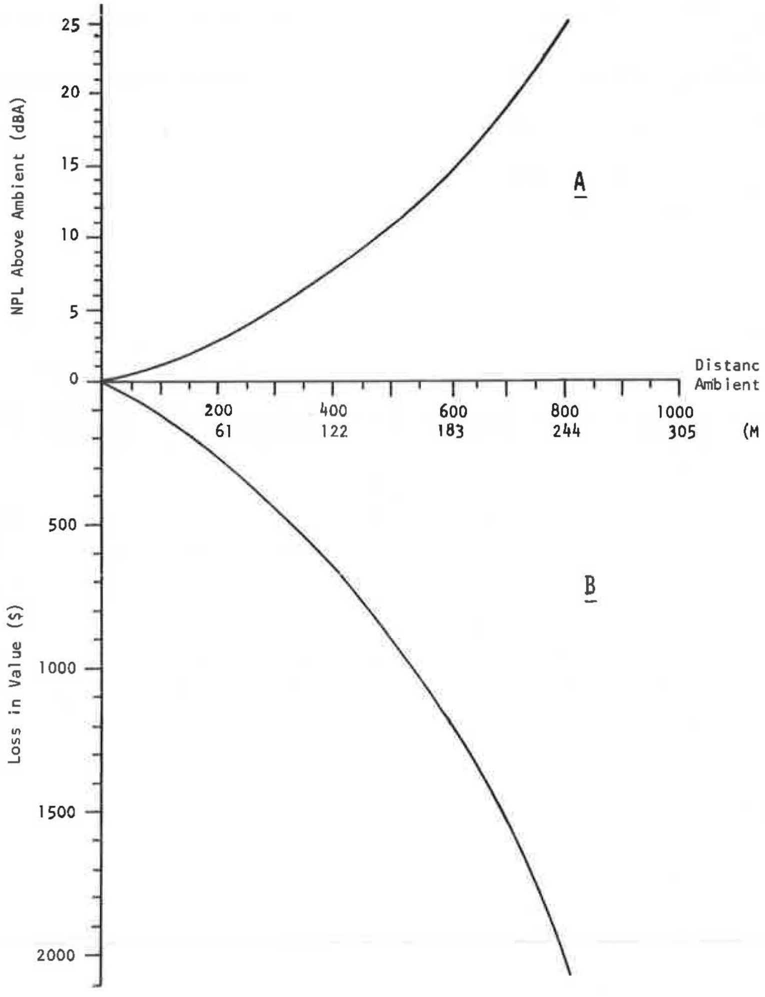
| Characteristic | Bogota | North Springfield | Rosedale | Towson | All Areas |
|---|---|---|---|---|---|
| Constant, dollars | 81,015 | 30,306 | 19,093 | 31,918 | 26,797 |
| Sample size[a] | 32 | 75 | 39 | 54 | 200 |
| $R^2$ corrected | 0.48 | 0.67 | 0.78 | 0.52 | 0.60 |

[a]Sample size refers to valid property sales.

**Table 6. Estimated effect of highway disturbances on value of abutting properties.**

| Characteristic | Bogota | North Springfield | Rosedale | Towson | All Areas |
|---|---|---|---|---|---|
| Average value of properties, dollars | 29,100 | 33,600 | 25,100 | 33,100 | 31,100 |
| NPL-NCHRP regression coefficient | -646 | -69 | -60 | -141 | -82 |
| Measured NPL, dBA | | | | | |
| Maximum | 77 | 77 | 80 | 80 | 80 |
| Minimum | 70 | 55 | 60 | 55 | 55 |
| Difference | 7 | 22 | 20 | 25 | 25 |
| Cost to abutting properties | | | | | |
| Amount, dollars | -4,522 | -1,518 | -1,200 | -3,252 | -2,050 |
| Percentage of decrease | 15.5 | 4.5 | 4.8 | 10.7 | 6.6 |

**Figure 2. NPL above ambient related to distance and loss in property value for all areas combined.**



where

$V$ = selling price of land plus improvements,
$H_1, H_2, \ldots, H_a$ = highway-related variables,
$N_1, N_2, \ldots, N_6$ = non-highway-related variables,
$X_1$ = dummy variable for Bogota, N. J.,
$X_2$ = dummy variable for North Springfield, Va.,
$X_3$ = dummy variable for Rosedale, Md., and
$X_4$ = dummy variable for Towson, Md.

Besides the highway-related variables, many other independent variables were used to explain variations in property values. A total of 95 variables were tested. The final results of the regression analyses for each study area and for all areas combined are given in Tables 4 and 5.

Several highway-related variables were significant in some of the intermediate regression equations, and a higher $R^2$ was achieved by using them. But the NPL variable appeared most frequently in the regression equations, and noise was the highway disturbance most frequently cited by people on the household survey. For these reasons and because of the high degree of multicollinearity between highway pollutant variables, NPL was selected as the highway-related variable for all equations. The regression coefficient for NPL shows that, for each increase of 1 dBA of noise, the value of property decreased a maximum of $646 in Bogota and a minimum of $60 in Rosedale. The average loss in value for all areas combined per dBA increase in NPL was $82. The difference between the lowest ambient level (55 dBA) and the highest NPL above ambient (80 dBA) in the sample of properties was 25. This difference times the coefficient of -82, or $2,050, is the amount, on the average, by which the price of a property abutting a highway was affected by highway-originating disturbance. This value represents a decrease of approximately 6.6 percent below the average price of properties in the four study areas. Table 6 gives the effect of highway disturbances on value of abutting properties for all study areas.

It should not be assumed that the values shown by the NPL coefficient reflect the adverse effects of noise only. The high degree of multicollinearity between NPL and CO level indicates that the NPL variable also accounts for some of the adverse effects from automobile emissions. The effects from these two major sources of highway disturbances could not be factored out in the regression model. It was hoped at the beginning of the study that the separate effects of noise and air pollution on property values could be identified, but this objective was not realized. This provides a worthwhile opportunity for future research.

The decrease in NPL is not linearly related to distance from the highway; rather, the rate of decrease in noise lessens as distance from the highway increases. The curvilinear relationship among NPL, loss in property value, and distance from the highway was developed for each study area. Figure 2 shows the results for all areas combined. Table 7 gives the loss in value related to dBAs above ambient and distance from the highway for all study areas.

The total losses for all properties in all areas combined amounted to about $2.2 million. The estimates of property losses do not necessarily indicate the total social cost or loss from adverse highway environmental effects. To the extent that some households may make expenditures to reduce noise, such as by insulating the home or installing storm windows, these costs are not included. Moreover, on a theoretical basis, consumer surplus may be an additional social cost not accounted for in the estimates given above.

Statistical analysis was performed on the relationship between perceived noise reported by residents in the four highway communities and noise measured by instrumentation as NPL. The regression coefficients for the above relationships were highly significant in almost all cases. The results are shown graphically in Figure 3. The close agreement between measured noise and perceived noise substantiates the usefulness of NPL as an indicator of disturbance from highway-generated noise.

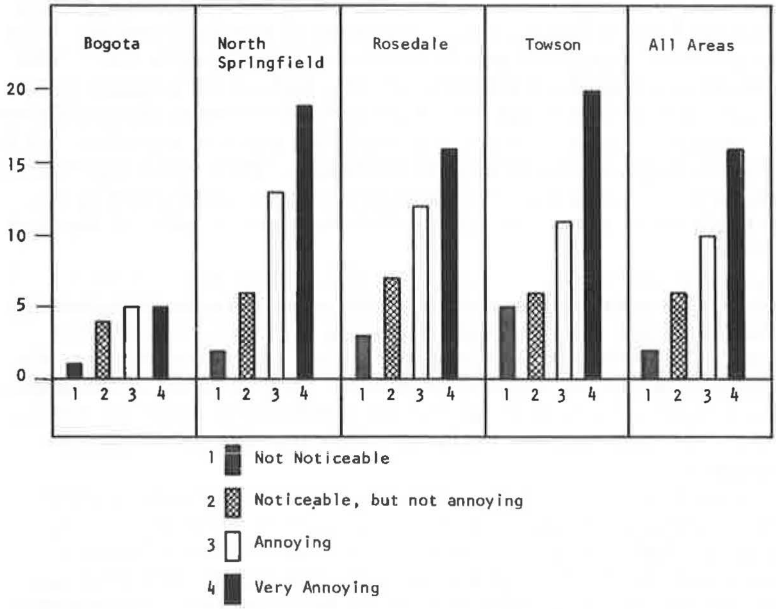
A worthwhile finding of this study not originally contemplated was a validation of the NCHRP highway noise prediction technique. It was found that, within the first 400

**Table 7. Loss in property value related to noise level above ambient.**

| NPL Above Ambient (dBA) | Average Loss in Property Value (dollars) | Distance From Highway to Ambient Zone (feet) |
|---|---|---|
| 25 | 2,050 | 800 |
| 24 | 1,968 | 785 |
| 22 | 1,804 | 755 |
| 20 | 1,640 | 720 |
| 18 | 1,476 | 680 |
| 16 | 1,312 | 635 |
| 14 | 1,148 | 585 |
| 12 | 984 | 530 |
| 10 | 820 | 470 |
| 8 | 656 | 410 |
| 6 | 492 | 330 |
| 4 | 328 | 240 |
| 2 | 164 | 130 |

Note: 1 foot = 0.3 meter.

**Figure 3. Average NPL above ambient for each level of perceived noise outdoors.**



feet (122 m), the field data and the predicted data (NCHRP) were within ± 3 dB. As long as the noise remained Gaussian in its distribution, the prediction technique could be used to fill in those areas in the study communities where field measurements were not taken.

NPL was used to define impact zones in each of the study areas. The ambient NPL contour lines in each study area were used to denote the boundaries between the impact zone and the control zone. The control zone, or the ambient zone, is that area in which highway-generated pollutants become so dispersed or absorbed into the environment that they have virtually no effect on the majority of people residing therein. The impact zone is the area within the community in which the highway effects are felt and many, but not necessarily all, of the residents are disturbed by these effects. Figure 4 shows the delineation of an impact zone for the Bogota study area.

The estimates of highway environmental effects on property values are really gross cost figures. To provide a more balanced and realistic view of the effects of a major highway on property values in a residential community requires that the influence of improved accessibility also be considered. The North Springfield study area was analyzed in depth for this purpose. The Metropolitan Washington Council of Governments (COG) has calculated accessibility indexes for two time periods, 1960 and 1968. These indexes, together with other variables, were regressed on the property sales data for Fairfax County to estimate the value conferred on residential properties by regional accessibility. Results indicated that a value of $197 was on the average associated with each one-hundredth unit increase in the COG index. In the North Springfield study area, the increase in the COG accessibility index was 0.15 from 1960 to 1968. The increase in value per property due to improved accessibility in North Springfield, then, amounted to about $2,950.

The findings are quite conclusive that in North Springfield the net effect of the highway was to raise the values of all properties, but the increase in the value of abutting properties was less than the increase in value of nonabutting properties because of the environmental effects of the Washington beltway.

The benefit conferred on each property in North Springfield from improved accessibility, primarily as a result of the Washington beltway, was about $2,950, or almost 9 percent of the value of the average property. The adverse highway environmental effects on abutting properties reduce the value by about $1,518 or almost 4.5 percent. Table 8 gives an indication of what the net effects on the entire community amount to and shows that the highway-induced benefits that property owners realize in North Springfield total about $5 million, compared to highway environmental costs of only about $303,000. This gives a net gain, considering all property owners together, of about $4.7 million.

## SUMMARY AND CONCLUSIONS

In summary, the study shows conclusively that for residential properties not within a narrowly defined interchange zone the adverse environmental effects of a major limited-access highway lower the value of properties near the highway as compared to properties more distant from the highway. In each of the four study areas examined, one or more highway-related variables, all with negative coefficients, proved significant in explaining variation in selling price of residential property. Noise is the most disturbing effect from highways, the one that people perceive most readily and frequently, and the one to which they object the most.

It is readily apparent that, if highway administrators and engineers are to mitigate the adverse effects of highways on neighboring residents, they must concentrate more effort on the reduction of noise. Significant reductions in noise generated by highway traffic may do much to reduce the objections now raised by many people living in highway communities or neighborhoods through which proposed highways will pass. Future development should be controlled near major highways. Land uses that are not adversely affected by highway noise could be permitted on lands close to highways, but residential, recreational, and other activities where quiet is desired could be restricted to sites in the ambient noise zone of the community.

**Figure 4. Highway environmental impact zone for Bogota.**


**Table 8. Net effects of highways on property values in North Springfield.**

| Distance From Highway (feet) | Number of Properties | Loss in Value From Highway Effect Per Property (dollars) | Gain in Accessibility Value Per Property (dollars) | Total Loss in Value, Highway Effects (dollars) | Total Gain in Value, Accessibility (dollars) | Net Effect of Highway on Property Values (dollars) |
|---|---|---|---|---|---|---|
| <150 | 5 | 2,100 | 2,955 | 10,500 | 14,775 | 4,275 |
| 150-300 | 87 | 1,350 | 2,955 | 117,450 | 257,085 | 139,635 |
| 300-450 | 87 | 825 | 2,955 | 71,775 | 257,085 | 185,310 |
| 450-600 | 109 | 550 | 2,955 | 59,950 | 322,095 | 262,145 |
| 600-750 | 96 | 300 | 2,955 | 28,800 | 283,680 | 254,800 |
| 750-900 | 96 | 125 | 2,955 | 12,000 | 283,680 | 271,680 |
| 900-1,050 | 88 | 25 | 2,955 | 2,000 | 260,040 | 257,840 |
| >1,050 | 1,126 | — | 2,955 | — | 3,327,330 | 3,327,330 |
| Total | 1,694 | | | 302,475 | 5,005,770 | 4,703,095 |

Note: 1 foot = 0.3 meter.

**Table 9. Current FHWA noise level standards and suggested standards.**

| Land Use Category and Activity | Present FHWA Standards[a] (dBA) | Suggested Standards (dBA) |
|---|---|---|
| A. Serenity and quiet mandatory | 60 (exterior) | 5 above ambient (exterior) |
| B. Residences, schools, churches, libraries, recreation areas, parks, etc. | 70 (exterior) | 10 above ambient (exterior) |
| C. Developed lands not included in categories A and B | 75 (exterior) | 15 above ambient (exterior) |
| D. Undeveloped lands | none[b] | none |
| E. Residences, motels, schools, churches, libraries, hospitals, auditoriums | 55 (interior) | 55 (interior) |

[a]From PPM 90-2, U.S. Department of Transportation, Federal Highway Administration, April 26, 1972.
[b]In special cases, standards may be applied to anticipated future land use activities on currently undeveloped land.

An approach to estimate the decreases in property values near highways as related to NPL and distance from the highway (Table 7) can be helpful to highway planners analyzing the costs and benefits of alternative highway locations or designs.

An important finding of the study is that the level of noise above the average ambient noise level for a community is more important than the actual noise level itself in the impact zone. Traffic generating an NPL of 85 dBA measured 100 feet from the highway in a community that has a low ambient noise level of, say, 55 dBA will disturb more residents to a greater degree than will the same highway in a somewhat similar community with a high ambient noise level of, say, 75 dBA.

The findings of this study suggest that the federal interim noise standards (PPM 90-2) should be revised. The present standards are in terms of absolute noise pollution levels. However, the difference between noise generated by the highway and ambient noise levels is more meaningful than the absolute level of highway-generated noise. The standards should be revised so that they are in terms of noise levels above the ambient level for the various land use categories. In this way the present noise characteristics and qualities of the community are taken into consideration and are better protected. Where costs of noise abatement are borne by the same society that would benefit from such noise abatement it would not be optimum in the economic sense to use a uniform noise level standard for all residential areas. A standard that takes into account the ambient noise level would be more efficient. The present standards (maximum permissible dBA's) should be adjusted downward. These suggestions are given in Table 9.

Economic analyses suggest that there would be a gain in economic efficiency if the standard were revised to specify that for residential land areas the maximum level of highway noise should not exceed the ambient level by 10 dBA. Using a figure of 10 dBA above ambient for a standard has further justification based on people's perceptions of noise as revealed in findings of the household survey. People reported that they were "very annoyed" when noise levels were more than 10 dBA above ambient.

Earlier studies were unable to uncover adverse impacts of highways on property values. This might be due, at least in part, to the general demand for a better environment becoming more popular in this country. This, together with the success of this research in uncovering and measuring the extent of the impact in four study areas, suggests that the social cost of highway-generated nuisances may be increasing over time. As efforts to improve the overall quality of the environment become more successful, there will be more insistent demands that most remaining highway-generated nuisances be eliminated. On a generally ugly landscape a single blight attracts little or no attention, but when that landscape is improved and becomes more attractive a single blot will stand out.

These considerations suggest that cleaner and quieter transportation will be required generally. In addition, the insulation of unavoidably noisy transportation from areas where noise is offensive may be necessary. The latter requirement implies the need for effective land use controls on the one hand or possible costly highway design features, such as underground or sunken arteries in central business districts, on the other. The costs of such systems may appear to be prohibitive at this time but may not be so in the near future. Increasingly strong objections to highway nuisances will have increasingly strong effects on the value of land where these nuisances occur. The tendency will be to increase the social benefits derived from the removal or avoidance of such nuisances. This, in turn, may justify the higher costs that will be required if the higher social benefits are to be realized.

The findings of this study imply that it is very desirable that government agencies be kept informed of the social costs and benefits associated with proposed highway constructions. Efforts such as those reported here should be refined and continually updated so that highway location and design decisions may be made on a more rational and objective basis with a view to minimizing the social costs of such projects and maximizing the social gains that may be derived from them.

## REFERENCES

1. Robinson, D. W. Towards a Unified System of Noise Assessment. Journal of Sound Vibration, Vol. 14, 1971.

2. Galloway, W. J., Clark, W. E., and Kerrick, J. S. Highway Noise: Measurement, Simulation, and Mixed Reactions. NCHRP Report 78, 1969.
3. Gordon, C. G., Galloway, W. J., Kugler, B. A., and Nelson, D. L. Highway Noise: A Design Guide for Highway Engineers. NCHRP Report 117, 1971.