Bulletin 95

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Demetrios Damianos
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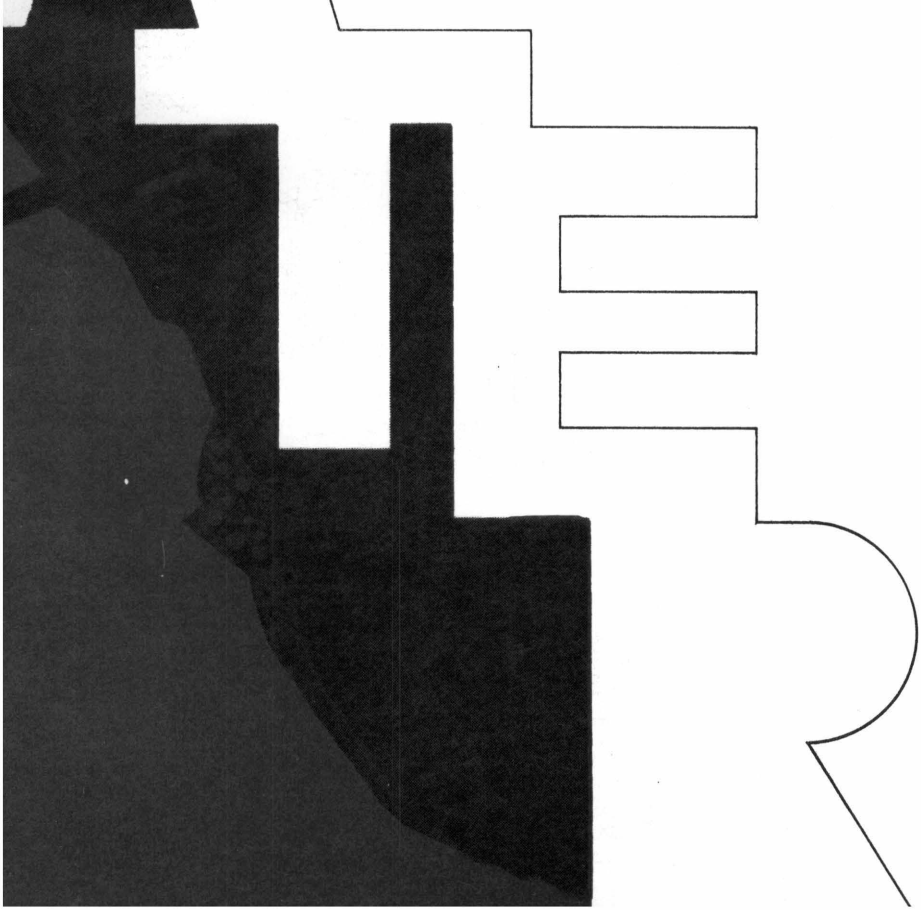

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# ABSTRACT

This research used a case study approach to examine the influence on residential land prices of two factors: (a) the presence of flood risk, and (b) the employment of structural or non-structural measures designed to minimize flood losses. The purpose was to see whether the influence of such factors on land prices could be isolated. Information of this kind would be useful in developing flood management policies that would lead to public support of the most efficient mix of alternatives for reducing flood damages. The market value of land, as used in this study, is defined within the context of an economic theory of land rent. The principal effort of the investigation was a statistical analysis of land sale prices directed toward isolating the influence of flood hazard. Two separate techniques of land value analysis were used. Results were generally consistent with the hypothesis that land sale price is negatively related to the potential of flood damage, and that erection of structural flood control measures enhances land prices. The researchers found, however, that it was impossible to isolate the influence of floodplain zoning measures on land prices. For this and other reasons, the results of this study are not considered conclusive enough to support definitive policy conclusions. As a guide to further research in this area, the techniques used in this study are critiqued and certain conclusions are drawn.

Key words: flood control, floodplain management, economic analysis, land use

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# SECTION I
# INTRODUCTION

The level of flood hazard can be viewed usefully as a joint product of the risk of a severe natural streamflow event and public policy adjustments for dealing with that risk [Russell, 1970]. In the past, policy adjustments have sought to reduce the level of flood hazard by modifying hydrologic occurrences through structures such as dams, levees, and channels. Recent policy activity seeks to broaden this structural approach to include non-structural alternatives which either modify damage susceptability by restricting and guiding floodplain land use, or modify the expected loss burden of those who suffer flood damage with disaster rehabilitation relief. More recently, another alternative has been promotion of purchase of flood insurance.

The alternative policies toward flood hazard are not mutually exclusive. A combination of two or more alternatives may be economically efficient, and identifying the most economically efficient combinations has often been the objective of past research [Day, 1973]. Yet, while the need to consider a broader range of alternatives has been recognized, governmental implementation of the most efficient mix of alternatives toward flooding has often encountered obstacles in the political arena. Numerous authors have argued that this "best mix" of flood damage management policies will be adopted only when the beneficiaries of programs are successfully tied to the costs of these programs [Haveman, 1973; Fox and Herfindahl, 1964; Milliman, 1969]. The general argument is that resource policies subsidize one distinguishable group of people at the expense of the general public treasury. This in turn provides the subsidized group with both "the incentive and the wherewithall to manipulate the political system to maintain the flow of the subsidy—whether or not an economic or social function is served and without regard to cost" [Haveman, 1973; p. 875].

For example, publically funded structural measures making a parcel of land flood-free, subsidized flood-insurance programs, and disaster rebuilding relief are all programs which add to expected income flows from flood-prone property and may be viewed as subsidies. On the other hand, public regulation of flood-prone land— restrictive floodplain zoning being one example— can reduce expected future income flows from a land parcel [Harris, 1971].

Thus, the landowner may be motivated to encourage public adoption of flood-hazard reduction measures which potentially enhance rather than reduce expected income flows from his land. Indeed the private landowner will not be alone in lobbying toward such goals. Historically, property-enhancing measures have been financed mainly by non-local government. As such, there is an incentive for local governments to support such property value enhancing policies to increase local property tax revenue.

Given this argument, it becomes important to identify changes in land values which result from alternative flood-hazard reduction policies. If such changes could be isolated, the validity of the above arguments would be tested; and policies of taxation or subsidy might be developed which would motivate political behavior toward a choice of an efficient mix of alternatives. In addition, alternative policies will most likely affect land values where land has the potential to be converted from lower per-unit-value uses, such as in agriculture, to higher uses such as residential or commercial use. Therefore in this study, land value impacts will be evaluated for residential land use.

## I. Previous Studies

### A. Flood Hazard Influences on Agricultural Land Values

Studies of flood-hazard effects on land values have primarily considered the influence of structural protection measures on the value of property used for agricultural purposes. Clarenbach [1954] examined the relationships between conventional benefit estimation techniques for structural protection measures and land prices in protected areas. Using economic rent theory he showed that if the conventional benefit estimates were accepted as correct, land which is subject to flooding should have almost no market value since estimated expected damage costs exceed the expected gross income that could be earned by the land. These findings emphasized the need to consider sale prices of land when estimating economic effects of flood hazard. Subsequently, analysis of land sale price differences between floodplain agricultural land and "comparable" flood-free land elsewhere, concluded that returns were higher on flood-free land than on floodplain land [Report of the Advisory Board, 1950]. Thus, the usefulness of a land price analysis was demonstrated along with a major methodological requirement for use of land price comparisons—namely, the need to compare areas that are similar for all non-flood hazard characteristics and different only in terms of flood hazard.

Subsequent research recognized that the empirical analysis of sale prices as a measure of flood-hazard effects can be most successfully accomplished through the use of regression analysis. Generally, a sample of land market transactions is drawn and the importance of factors influencing sale price of the land parcels is determined through use of a general estimation model of the following form:

$$P = b_o + b_1 X_1 + \ldots + b_n X_n$$

where P is the land sale price, and $X_1, \ldots, X_n$ are selected explanatory variables of the sale price, such as size of parcel, value of improvements and degree of flood hazard. The regression coefficients, $b_o, \ldots, b_n$, are direct measures of the importance of each variable in explaining land sale prices. For example, Waldrop and Badger [1968] evaluated changes in agricultural land values in three structurally protected watersheds. The sale price of a complete land parcel was made a function of the acres of floodplain cropland, the acres of flood-free cropland, the assessed value of farm improvements, the mineral rights transferred and variables representing time of sale and location. Their findings indicate that the sale price of land parcels rises as the amount of flood-free cropland increases due to additional structural protection.

A variation of the simple regression technique is the land sale comparison method which examines the difference in sale prices of land that are comparable along all dimensions except level of flood hazard. The differences in prices can then be attributed to the existence of flood hazard [Boxley, 1969]. After theoretically determined explanatory variables are identified, a multiple regression is used to estimate the influence of the several variables on flood-free land sale prices. Thus the coefficients for the resulting regression equations are considered free of any discounting for flood hazard since the flood hazard is non-existent for the selected land sales. Then, using the regression coefficients derived from the analysis of flood-free land sales, and mean values of the explanatory variables for parcels *subject to flood hazard*, an average sale price for *flood-hazard* land is then predicted. The assertion is that in the absence of flood hazard, the average sale price of land subject to flood hazard would be influenced by the explanatory variables in the same way as the flood-free parcels. By subtracting the actual flood-hazard average price from the predicted average price, the difference attributable to flood hazard is determined. Applications of the land comparison technique isolated the effects of both flood damages and structural protection works on agricultural land values.

## B. Flood Hazard Influences on Residential Land Values

A recent study sought to isolate the effect of flood risk on property values in St. Louis County in 1974 [Greenberg et al., 1974]. The sale price and the sale price plus the appropriate property tax were used as dependent variables in a regression model to predict land sale prices with a dummy variable included for sale observations located on floodplains. The coefficient of the dummy was of the expected negative sign and was significant, demonstrating the effect of flood potential on land values. However, no attempt was made to examine the effect of public policies on land prices.

Another study of residential land prices assumed that the price for a particular residential site is determined by its accessibility to economic activities, its amenities, its size, and its location relative to the floodplain [James et al., 1971]. The land comparison technique was applied and the results indicated that residential lot prices in the study area were significantly discounted if they were subject to flooding. As in the St. Louis study, no attempt was made to isolate the effect of public policies on residential property values.

## C. Implications of Previous Studies

The existence of different levels of flood hazard does affect agricultural land sale values. However, there is a need to isolate the effect of flood hazards by controlling for other influences on land prices. In the previous work, a gap in information exists on how policies toward flood hazard affect *residential* property values. The multiple regression procedures adopted in most of the above studies for estimating land value effects have proved promising, and suggest that further use of this technique is justified. The major conclusion, therefore, is that statistical analysis of land market sales may be capable of recognizing flood hazard with respect to residential land price and may provide an indication of the expected impact of alternative policies toward flood hazard in residential areas.

## II. Objectives

This study will seek to determine the impacts of alternative levels of flood hazard on residential land values. Then, by extension, this study will draw inferences for the public choice process governing the adoption of flood-hazard policies.

More specifically, the project objective is to empirically estimate the influence of flood-hazard reduction alternatives on sale prices of residential land.

## III. Contents

In Section II a model of flood hazard effects on property values will be formulated. Then, the research procedures and the specific methodology applied will be discussed in Section III. Also in Section III, attention will be devoted to the theoretical consideration of the relevant variables that should be considered as well as some conceptual issues involved in measurement and statistical analysis. In Section IV, the results of analysis of case studies will be presented. Section V will include conclusions concerning the effect of flood-hazard on residential property values as well as a critical review of the concepts and methodology developed for this study.

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# SECTION II
# DETERMINANTS OF LAND PRICES

The presentation of a model of land price determinants will provide the study with empirically testable hypotheses, and will guide and logically control the interpretations of all statistical results and their extensions. Conventional graphics are used for illustrating the determination of land rents as a starting point in the discussion of price determination for residential property [Pendleton, 1968; Renshaw, 1961; Turvey, 1957]. The conceptualization of the impact of flood potential and policies toward flooding on residential property values can then be facilitated.

**I. The Market Value of Land: Relationships to Land Rent**

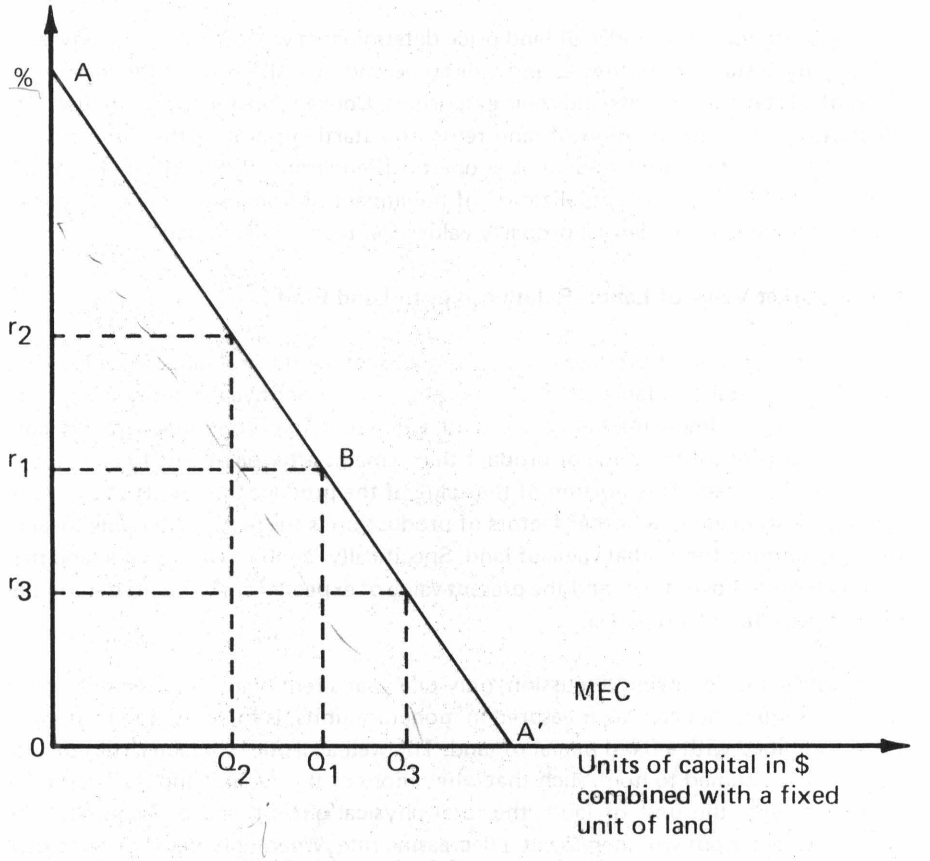
Land, as one factor of production, is distinct from capital and labor insofar as it is immobile. Capital and labor are free to move in a competitive economy in order to capture their maximum market value. Land, when used in production, can only control that portion of the value of product that remains after payments to capital and labor are deducted. This portion of the value of the product that is left in excess of the payments made to all other factors of production is the rent attributable to land. Rents determine the market value of land. Specifically, annual rents from a land parcel are expected over time, and the present value of expected annual rents determines market price for a land parcel.

To simplify the following discussion, only one year's rent will be considered, and it will be assumed that capital, measured in monetary units, is the only non-land input to be combined with a fixed parcel of land. The well accepted characteristics of production are assumed to hold, such that when more of the variable input of capital is combined with the unit of land, the total physical output, and consequently the value of total output will increase at a decreasing rate. When only net returns to capital are considered, the total net revenue will increase at a decreasing rate and the marginal net returns will be a decreasing function of units of capital combined with a given unit of land. The sellers and purchasers of flood-prone lands are assumed to have perfect knowledge about the magnitude and frequency of flood flows. They are also assumed to be risk neutral in their attitude toward flooding. It is also assumed that floodplain occupancy choices do not create significant externalities.

Figure 1 illustrates the general framework for analysis. The units of capital are measured on the horizontal axis in dollars. On the vertical axis is a percentage figure which can measure the marginal rate of return on the capital invested as well as the market rate of interest. AA' is a marginal efficiency of capital (MEC) schedule which represents the marginal rate of return on additional increments of capital.

The rate of return is computed following the standard capitalization formula of:

**FIGURE 1**
**Rent to Flood-Free Land**




$$K = \sum_{t=1}^{T} \frac{R_t - C_t}{(1 + i)^t}$$

where:

- K = measurement of invested capital on a given land parcel as shown on the horizontal axis in Figure 1;
- T = life of the capital investment;
- $R_t$ = gross returns from use of capital in combination with land in year t;
- $C_t$ = cost of operation for capital in combination with land in year t; and,
- i = rate of return in percent.

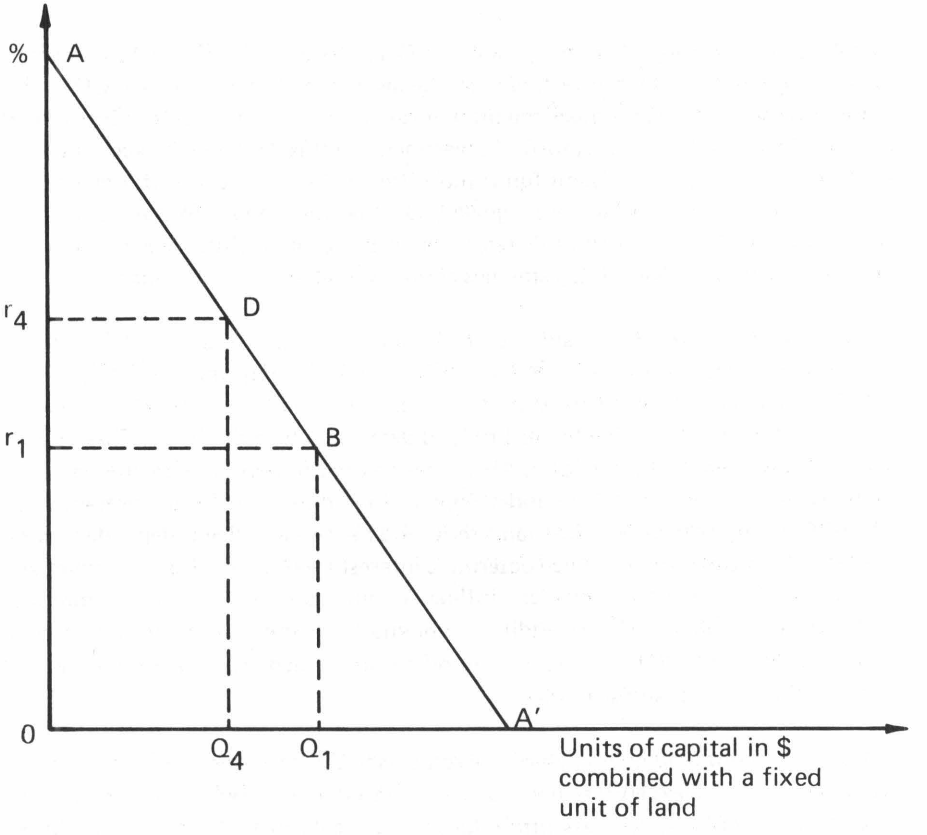
The marginal rate of return, r, shown on the marginal efficiency of capital schedule AA′, in Figure 1, is simply the change in i with respect to a change in K. Since the verticle axis measures percentages, the area under the MEC curve corresponds to a fraction of the money sum shown on the horizontal. Thus, the MEC curve also can be used to show changes in money returns, with total returns represented by the area under the MEC curve from the origin to the point on the horizontal axis corresponding to the units of capital entered into the production process.

Assume a market rate of interest equal to $Or_1$, as shown in Figure 1. The profit maximizing level of capital investment on the given parcel of land is then $OQ_1$. This is the level at which MEC equals the market rate of interest. At levels of investment less than $OQ_1$, say $OQ_2$, the return of investment on this land parcel exceeds the return for other uses of investment funds (i.e. exceeds the market rate of interest) and hence further capital outlays are signaled. On the other hand, to push outlays to $OQ_3$ results in a return on that incremental unit of capital which is below the market rate of interest. Hence, $OQ_1$ emerges as an optimal level of investment.

At $OQ_1$ total returns to investment on the given land parcel are $OABQ_1$. This is composed of the opportunity cost of invested capital $OR_1BQ_1$ and the triangle $r_1AB$ which is the residual return to land, or the land rent. That is, the land rent is the return to investment on a fixed parcel of land *over* the return on capital. The present value of the annual amounts of $r_1AB$ is the maximum market price the parcel of land would command if it were undeveloped. Upon development, the present value of $OABQ_1$ is market price. Thus land rent, and hence sale price is dependent upon forces in the capital market which determine interest rates and forces in product and non-capital factor markets which can influence annual gross returns ($R_t$, Equation 1) and costs ($C_t$, Equation 1). In addition, non-market factors which influence gross receipts, costs or interest rates, such as flood hazards which increase expected annual costs, will also affect land sale price.

Consider a unit of land comparable in all respects to the one examined in the previous discussion, with the exception that it is located on a floodplain where it is periodically subject to flooding. A business firm choosing to locate in the floodplain considers the impact of future floods on operation costs ($C_t$, Equation 1) including cleanup, replacement, and interruption of operations. That is, the expected flood damage represents an annual cost for the use of capital at the particular location. As this expected cost increases, the MEC curve in Figure 1 will shift leftward, indicating a lower rate of return for any given level of capital invested at the land site. Alternately, the cost of expected flood damages can be viewed as requiring an increase in the marginal rate of return on capital invested on the floodplain to be higher than capital invested off the floodplain. The later view will be adopted here and is shown in Figure 2. The required rate of return for investment on the land parcel rises from $Or_1$ to $Or_4$ due to the potential for flooding. This reflects both the opportunity cost of capital of $Or_1$, plus $r_1r_4$ which is the penalty imposed by the flood potential. The result is to decrease the optimal level of investment from $OQ_1$ to $OQ_4$. Thus, with the existence of flood damage potential, total returns to the optimal level of investment are $OADQ_4$ with the land rent of $r_4AD$. Thus all other factors held constant, comparable areas of land with the exception that one is flood-prone, will result in different annual rents and command different market prices.

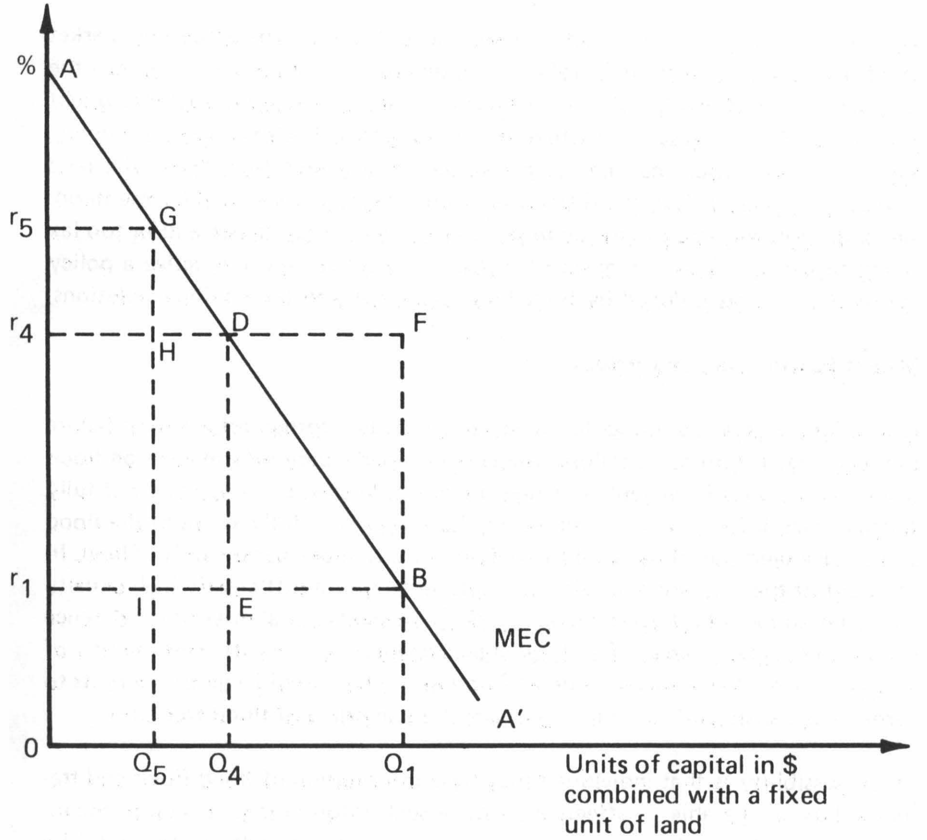
**FIGURE 2**
**Rent to Flood-Prone Land**




The influence of policies toward flooding on rents, and thus sale prices of land can be determined within this framework. Policies which modify flood flows to reduce expected damage or the burden of the loss, when paid for by individuals other than the floodplain occupant, will reduce $C_t$ in Equation 1 and thus the gap between the market rate of interest and the required rate of return on capital. This will encourage increased capital outlays in the floodplain, increasing land rents and higher sale prices. The previous discussion of Figure 2 can be reversed to demonstrate this effect as the required rate of return for investment on flood-prone land, $r_4$, moves closer to the market rate of interest, $r_1$.

Alternatively, policies which reduce damage susceptibility through restricting capital outlays on land may reduce land rents and sale prices. The analysis of such policies can be accomplished with Figure 3. Given that the potential for flood damage exists, the optimum level of development was shown as $OQ_4$, in Figure 2. However, due to ignorance of the potential for flood damage, investors may seek to expand investment

**FIGURE 3**
**The Effects of Modifying the Damage Susceptibility Measures**




to $OQ_1$ with the result that "over-development" of the flood-prone area occurs.[1] This "over-development" can be seen in Figure 3 at $OQ_1$. The expected marginal net returns from expansion beyond $OQ_4$ are EDB. However, the existence of flood damage potential is represented by the area EDFB which exceeds EDB[2]. Thus, the net returns from expansion of capital investment are less than the incremental flood damage costs. An optimum zoning policy would restrict development to $OQ_4$ and a land rent of $r_4$AD, precisely where it would be with the knowledge of the existence of damage costs. Alternatively, the existing flood hazard may be overestimated by public decisionmakers, and investment can fall short of the optimum amount. For example, zoning may restrict investment to $OQ_5$. Rent falls from area $r_4$AD to

[1] More discussion of the problem of ignorance of flood risk is presented below. This argument involves a relaxation of the "perfect knowledge" assumption made earlier.

[2] Consider that $R_1R_2$ represent the interest rate penalty imposed by flood damage potential. Expansion from $Q_4$ to $Q_1$, in fact, then suggests a flood damage cost expectation of EDFB.

$r_5AG$. Thus, the policy has served to decrease rents by $r_4r_5GD$ and, by extension, the market price of the land will fall due to the zoning policy.

Thus, a restriction on capital investment may lead to a situation where the market price of a land parcel accurately reflects the discount for flood potential. On the other hand, too restrictive a policy may decrease land prices beyond what they might otherwise be. This suggests that where flood-prone land is also subject to zoning, analysis of market prices can be subject to varied interpretation. First, the land price may accurately reflect the difference in rents that can be earned by the flood-prone lands. Second, sale price may reflect the risk by the purchaser and/or too lax a zoning restriction. Third, a given land price may reflect too restrictive a policy which results in rents reduced by both flood potential and the zoning regulations.

**II. Market Failure and Land Values**

Market failures relevant to floodplain land value take two forms: information failure and externality. Information failure occurs when inadequate information on flood flow and frequencies is available to land purchasers, or such purchasers do not fully understand such information. If a single purchaser were not fully aware of the flood potential of a land parcel he would be willing to pay more for the unit of land. In the context of the previous analysis, he would not place a sufficiently high penalty on the required rate of return and would seek to increase capital intensity and hence land rent on the given parcel. If such ignorance characterized a sufficient number of purchasers the market transfer value of flood-prone land could exceed the rents to be earned from such land, and may approach the sale prices of flood-free land.

Another possibility is that individuals may have information of flood flows and frequencies, but not be able to effectively utilize such information. It is up to the individual land purchaser to convert such information into a penalty to attach to the rate of return calculation. However, a lack of understanding of the concepts of probability and risk may result in ineffective use of such informaiton. Insofar as the potential for flood damage is underestimated, market prices may overstate the rents to be earned by flood-prone lands. If the potential is overestimated, the opposite result will occur.

Externality can occur when the choice to purchase and develop a flood-prone land parcel directly affects some other landowner by directly increasing their possible flood damages. For example, stream channelization may increase flows downstream causing damages to one property in order to protect another. Such externalities are not reflected in the market price of land transfers. While the market price of the parcel may reflect the rents to that parcel, the total rents to all lands along the stream will not be reflected in the market price of the single parcel transferred.

While not exactly a case of market failure, relaxation of one assumption made above would alter the conclusion about the parallel between market price and land rents. If purchasers of parcels are not risk-neutral, they will react to the probability of flooding in a way which will either increase or decrease the penalty they attach to the rate of return calculation. A risk-avertor would be likely to increase the penalty provision and pay less for a property than the expected value of the rents which could be earned. A risk-taker would do the opposite. The implication is that deviations from risk neutrality by the land purchaser will result in market prices which may not accurately reflect the affect of the level of flood hazard on rents.

The considerations of market failure do not bear on the empirical efforts of this study. However, the interpretation of the empirical results will be affected by these factors.

**III. Residential Land Value Determination**

The general theory of economic rent discussed above implies that the market price of land depends upon its expected future monetory earnings, since potential land buyers consider personal financial gain as their sole motive. In many cases this assertion about financial gain is well founded—for example, when land is used for agricultural purposes. The reasons are straightforward: farmers utilize farm land for the purpose of obtaining income. When flooding works against land's ability to yield crops, the expected economic gains are reduced and land's value decreases.

However, some question has been raised about whether land prices reflect flood hazard for residential land. Kates [1962], for example, argues that there is no evidence to indicate a responsiveness in land values or rent toward flood hazard. Another study [James, 1971] argues that the effect of flood damage on urban property values is not as closely linked in a quantitative sense to losses during flood events, as it is for cropland.

In choosing a residential site, expected profit from resale and the additional expenditures required to repair damages due to flooding should not be discounted as effecting sale price. However, the profit motive or financial advantage is not the only factor that affects individual homeowners in choosing a residential site. Non-pecuniary factors such as neighborhood amenities and physical characteristics of the property are of significance in determining net returns to the purchaser's overall "satisfaction" with the location. In short, the land purchase decision, when motivated by profit, is simply a production decision, with the determinants of profit easily converted to monetary costs and returns and reflected in the MEC schedule discussed above. The residential location choice, on the other hand, may be motivated by a utility maximization objective within which the costs and returns framework may have a different interpretation. Indeed, the demand schedule for residential land development may be conceived of as a marginal utility schedule as opposed to a marginal efficiency of capital schedule.

The Lancasterian framework for consumer behaviour provides a useful way of linking the two concepts [Lancaster, 1966]. In his framework it is not goods themselves that are the direct objects of utility; utility is found in the properties, attributes or characteristics associated with the goods, and it is these characteristics that are of direct relevance to utility. Characteristics, after being objectively allocated to goods, (or combinations of goods) are subjectively ranked by each individual consumer. The consumer has a unique preference ordering over all possible vectors of characteristics. As in traditional consumer theory, his objective is to maximize his utility subject to the relevant constraints of cost and budget. The demand for goods therefore, is derived demand since goods are desired for their characteristics. As such, consumption is regarded as a production process in which goods are entered as inputs and costs, and out of which characteristics exit as outputs and returns. The implications of Lancaster's theory for residential land prices is that the demand for the services of residential housing location is a function of a set of characteristics which create net utility, of which freedom from flooding is one. Therefore, the returns to residential land parcels may include such characteristics as site amenities, accessibility to economic activities, historical factors, topography, expected resale value, as well as the characteristics embodied in the improvements on the site. A slightly different perspective can be gained by separating the site value from the improvement value. To capture the site characteristics a residence must be available at the site. The cost of the residence represents a type of capital outlay necessary to capture the site characteristics. Thus, the difference between the "return" on capital improvements and total purchase price of a residential site will reflect the "rent" earned by the bundle of characteristics of the land site itself. As such, the utility based "rents" to various residential sites can be compared, and this comparison of "rents" will capture residential site characteristics insofar as the characteristics of the capital improvements are homogeneous between the sites. In the context of this study, potential flood damage is viewed as a negative influence on the willingness to make capital improvements on a site subject to flood damage. Thus, the basic model of land rent and price will be assumed valid for residential property, although the basis is the production of consumer utility and not profit potential.

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# SECTION III
# PROCEDURES

The previous discussion suggested that flood damages themselves, and policies to deal with such damages, affect the present value of expected annual rents of purchasers of flood-prone lands. Therefore, the sale price of land will reflect the level of flood hazard (flood damage potential and policies toward flooding). Based upon that discussion, the following three hypotheses were developed:

1. The sale price of lands will vary inversely with potential flood-damage costs.
2. Structural flood control measures will enhance the sale value of previously flood-prone land.
3. Restrictive zoning measures will reduce the sale price of flood-prone land, beyond the reduction due to the flood-damage potential.

To test these hypotheses, analyses of land sale prices were conducted.

Price predicting regression models, which viewed the price of a residential parcel as a function of site and improvement characteristics, including flood hazard, were utilized to test the hypotheses. The use of regression analysis to analyze the effect of the explanatory variables on sale prices was of two forms.[1] First, regression analysis of floodplain land sales was conducted, and variables were included to represent the existence of flood hazard and of selected policies. The coefficients of the variables served as direct estimates of the influence of flooding and the given policy on land sale prices. The statistical significance of the coefficients was to test the hypotheses of this study.

The land comparison technique, discussed earlier, was also used. This approach examines the difference in sale price of lands that are comparable along all dimensions except flood hazard. By asserting that in the absence of flood risk, the influence of identified determinants of the sale price of both flood-free and flood-hazard lands would be the same, a technique for dealing with non-comparability of land parcels is derived. A multiple regression model is applied to flood-free land sales to estimate the influence on sale value of several explanatory variables. A mean sale price for flood-prone land is then predicted using the regression coefficients derived from the analysis of flood-free parcels. By subtracting the actual floodplain average price from the predicted average price, the difference attributable to a flood risk location is estimated.[2]

[1] For a discussion of the use of regression analysis in price prediction see Stull [1975].

[2] This comparison cannot be accomplished, if, for example, the average sale price of land parcels in a floodplain is simply subtracted from the average price of parcels sold in a flood-free area. The result is an "unadjusted" difference in sale price, and this unadjusted difference in price cannot be interpreted as a difference due to flood risk alone, because the parcels in the two areas are not usually comparable along other dimensions. For example, differences in parcel size or in the value of the improvements will be reflected in the unadjusted sales difference.

**TABLE 1**

**An Example of the Derivation of the Difference Attributable to Floodplain Location Using the Land Comparison Method**

| | |
|---|---|
| 1. Average Price of Flood-Free Parcels | $8,000 |
| 2. Average Price of Flood-Prone Parcels | 6,000 |
| 3. Unadjusted Difference | 2,000 |
| 4. Predicted Price of Flood-Prone Parcels | 8,500 |
| 5. Difference Attributable to Floodplain Location (4-2) | –2,500 |

An example of the land comparison method is shown in Table 1. Lines 1 and 2 show the average current sale price of parcels in flood-prone and flood-hazard areas. In line 3, the unadjusted $2,000 difference shows the result of the combined effects of all factors which influence sale price such as lot size and value of improvements, in addition to flood risk. Line 4 shows predicted price for flood-prone parcels based upon regression coefficients from the analysis of flood-free land parcels. With an $8,500 predicted price and an actual price of $6,000, the difference in price attributable to flood hazard is shown in line 5.

Although both these uses of regression techniques can provide a basis for controlling the influence of variables which affect sale price, it is often cumbersome to measure and introduce "all" relevant variables into a regression equation. As such, two approaches were used to control for characteristics which might influence sale price of a land parcel. Whenever possible sales were examined from case study areas where characteristics of land parcels were as homogeneous as possible. This was insured by taking sale observations from geographically small areas, generally not exceeding a few city blocks. Thus, variability in sale price would not be influenced by these characteristics since they were essentially uniform over all observations, and measures of such characteristics could be eliminated from a price prediction equation. When this was not possible a measurement of the characteristics was introduced directly into regression equations.

### I. Selection and Measurement of Explanatory Variables

The initial step in implementing the analysis was identification of the residential site and improvement characteristics that may influence sale price. The site characteristics were classified into five major headings: (1) accessability, (2) topography, (3) historcal factors, (4) improvements, and (5) site amenities.[3]

[3] It has become almost "standard practice" in the literature on determinants of property values to use this type of approach to variable selection. See Stull [1975].

*Accessibility* characteristics included proximity to commercial centers, parks and open space, and to highway access points. Whether there would be a positive or negative influence on sale price was not of concern, since all lots that were studied were selected so as to be equally affected by these factors. Thus, these characteristics were not included in the regression analysis.

*Topography* of the land parcels includes slope and elevation. Within the floodplain all parcels were generally of the same configuration and none were observed to be elevated above any others. Flood-free areas for use in the land comparison method were selected to have as little variation in topography as was possible. Thus, no topography measures were included in the analysis.

*Historical factors* are changes in the general price level, and market demand and supply influences such as local property tax levels, that can influence prices. At times these factors can be considered by utilizing a price index as a deflator. However, adjustment may still have to be made for local variations in demand and supply of housing. The residential property prices examined in this study are sets of time series data. In order to adjust for changes in the local conditions, a variable taking the value of 1 if a sale took place in the first year of the time span considered, and increasing by one for each year thereafter, was included in the models. Therefore, the year of sale was assumed to be positively related to the price of residential property.

*Improvements on the lot* are one of the main sources of variations between sale prices. The tax assessor's value of the buildings on the land parcel provided a general measure of such differences. To assure that monetary differences did reflect differences in the qualitative characteristics of the houses, the physical characteristics of the housing units were compared according to the size of the house, the number of bathrooms, and the age of the house. In virtually all areas sampled, the houses being compared were homogeneous with respect to these physical characteristics.

*Site amenities* are qualitative factors that cannot be easily quantified. Several variables were considered here to examine the amenity level which characterized each lot. Community characteristics, including resident income, age of the structures, and racial composition, can affect sale price of a land parcel. Interviews with residents and public officials, observations, and inferences drawn from sale prices of land parcels suggest that the case study areas were homogeneous in income, age, and racial characteristics. Such being the case, measures of these factors were not included in the regression analysis.

The size of the lot is expected to be related to the price of residential property in a positive manner. The basis for this belief is the fact that larger lots increase the quantity of housing services provided by yielding more building space, thus increasing the site value. In addition, larger lots improve the quality of housing services as well by providing such values as comfort and privacy. The lot size is used as an explanatory variable in most regression equations.

Corner lots provide greater exposure to sun and air, greater access to on-street parking, better view and more privacy. However, greater exposure to traffic and noise could be considered as offsetting factors. Where corner lots are a significant portion of the sample of sales drawn, this characteristic was included in the regression analysis.

The effect of flood hazard is the key concern in this study. Recall that the level of flood hazard is a *combined* effect of the flow of the stream and human adjustment to flood potential. Thus, in some instance, the flood hazard characteristics was represented by two variables—one to represent streamflow and the other to represent the flood damage policy in effect. However, there is no accepted form that the flood hazard variables might take when included in a regression analysis.

Some studies have used a 0-1 dummy variable indicating the floodplain vs. off-floodplains location of each property [Greenberg et al., 1974]. For this study, a 0-1 dummy variable was used to represent the existence of a policy toward flood damages. This usually is accomplished by letting sales made before the policy was in effect take on a value of zero and those after the policy take on a value of 1.

The measure of expected flood damage potential that was utilized combined the effect of the flood water itself with an assumption about the human perception of the risk. The variable used to measure flood potential assumed that the effect of flooding on land prices would be discounted by the number of years elapsed between the time of previous floods and the land sale.[4] After identifying the cfs (cubic feet per second) discharge that characterized a "minor" flood, all discharges of that magnitude and greater were incorporated into a measure of flood risk.[5] The variable was:

$$\sum_{i=1}^{N} \frac{C_i}{t_i^2}$$

where:

- $i$ = a single streamflow event greater than or equal to a minor flood, occurring during the time period for which sales were sampled;
- $N$ = total number of all streamflow events greater than or equal to a minor flood;
- $C_i$ = intensity of a flood, i, measured in cubic feet per second discharge at the stream gage nearest to land parcel; and,
- $t_i^2$ = the square of time elapsed since streamflow event i. Time is squared to emphasize recent flood events.

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[4] This variable does assume "perfect" information about historical flood events by the land purchaser. Later discussion will consider this assumption.

[5] The term "minor" is a relative concept that was defined in hydrologic terms during conversations with hydrologists in the U.S. Army Corps of Engineers. It was assumed that a fixed linear relationship existed between discharge in cfs and economic damages caused.

Each sale had a measure of the above variable associated with it to represent the expected effect of flood damage.

Thus, while a number of different characteristics which determine sale price have been identified, only a limited number will actually appear in the regression equations used in this study. Sale price will be made a function of time of sale, size of lot and assessed value of improvement. Where appropriate, a corner lot variable and a flood hazard variable are included. All other characteristics that may influence sale price are controlled for thorough sampling from homogeneous case study areas.[6]

**II. Selection of the Areas of Investigation**

The primary criterion for selecting case study areas for investigation was to represent three major flood hazard situations, namely, no policy in effect to deal with floods, modifying the flood (structural measures) and modifying the damage susceptability (zoning).

Analysis of residential land sales data for Roanoke, Radford and Alexandria, Virginia, was conducted. In Roanoke, floodplain land along the Roanoke River that has been affected by neither structural or non-structural measures was studied. In Radford, land along the New River which was subject to severe flooding prior to construction of Claytor Lake Dam was the focus of study. In the Four Mile Run area of Alexandria, the severe flooding problems were dealt with by the imposition of a zoning ordinance which limited further development within the floodplain. Thus both structural and non-structural alternatives for dealing with flood potential were examined.

Land sale prices, assessed value of improvements, size of the parcel, location of parcel, time of sale, degree of flood hazard, and a careful review of general community characteristics encompassing the broad range of characteristics noted above, were basic data needs for both the regression analyses and finding homogeneous properties. Land sale price data is available through courthouse records, as is information on year of sale, assessed value of improvements, size of land parcel and location of parcel. In addition, information on housing characteristics such as rooms and baths, is sometimes available from these sources. Community characteristics were checked through observation and detailed discussions with public officials. The same public officials provided information on policy action taken to deal with flood potential. Maps prepared by the U.S. Department of Housing and Urban Development, along with studies from the Army Corps of Engineers and the Virginia Division of Water Resources, were used to delineate areas within the 100 year, and in one instance 500 year, flood-

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[6] One intention of this study was to minimize the need to include variables other than flood hazard in regreesion equations. However, some equations were run with more variables to determine whether inclusion of variables other than those listed above would influence the regression results. In each instance the results were less satisfactory than those obtained with the equations presented here.

plain. The areas selected for study were small so that the flood hazard was uniform for all lots. (See Damianos [1975] for more detailed information.)

A questionaire was also administered to current occupants of floodplain housing in Roanoke and Alexandria. The questionaire sought to investigate the perception of flood hazard by purchasers of residential parcels, and to check on the homogeneity of the site improvements and the community characteristics. Such questionaires were addressed to current land owners only, and explain conditions prevailing at the last sale only and not in any previous ones that might have been included in the regression analyses [Damianos, 1975].

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# SECTION IV
# EMPIRICAL ANALYSIS

This section reports on the findings of three case studies. The Roanoke case study assessed the impact of flood hazard when no floodplain policy is in effect. The Radford case study examined the impact of a structural policy measure, and the Alexandria case study will focus on floodplain zoning.

**I. Roanoke**

Wasena Park and South Roanoke Park residential areas are located next to Roanoke River, but are at a distance from each other. Within each residential area the 100 year and 500 year floodplain boundaries were identified and sales were observed for both areas.[1] Flood-free areas chosen for application of the land comparison method were adjacent to each flood hazard area, respectively, and had characteristics that were similar to the floodplain. Sales between the years 1945 and 1974 were analyzed to isolate the effects of flooding potential alone on land sale prices, since no policy toward flooding had been adopted during this period.

First, regression equations, estimated for flood-free land sales in each area, were used to predict floodplain sale prices for a land comparison analysis. The average sale price of all flood-prone residential parcels was predicted using the coefficients of the regression equation for the flood-free parcel sales, and the average values of the explanatory variables for parcels situated in the entire floodplain area. The same calculations were then done separately for floodplain lots situated in the 100 year and 500 year floodplains, with the expectation that land value differences due to flooding would be greater in the 100 year floodplain than in the 500 year floodplain.

Next, a flood potential variable (Section III) was included in a regression analysis that sought to explain variation in sale price over time within the 500 year floodplain. The statistical significance of the flood potential measure, as an explanatory variable of land prices, was tested with the expectation that it would explain variation in sale price over time within the floodplain.

A. Wasena Park Area

Equation 1 was estimated for use in the land comparison technique.

$$\begin{array}{llll} \overline{Y} = 5518 & + 81.66\,(X_1) & + 3.03\,(X_2) & + .23\,(X_3) \\ & t = 2.35 & t = 13.61 & t = .82 \\ & \alpha = .0135 & \alpha = .0025 & \alpha = .15 \end{array} \qquad [1]$$

[1] Once case study areas were selected, all market transactions within the area between specified time periods were incorporated in the regression analysis. Thus within case study areas, all transactions were included in the regression analysis of land sale prices.

$\overline{R}^2$ = .80 (multiple correlation coefficient corrected for degrees of freedom)
$\overline{Y}$ = (mean sale price) = 11128, n (number of observations) = 74
Sy = standard error of the estimate) = 1952
D.W. (Durbin Watson Statistic) = 1.96

where:

Y = nominal sale price of residential parcels
$X_1$ = year of the sale
$X_2$ = assessed value of improvements at time of the sale
$X_3$ = size of the parcel

The high $\overline{R}^2$ indicates that the equation accounts for much of the variation in sale price of the flood-free parcels. The coefficients of year of the sale and the assessed value of improvementsmeasures are statistically significant at the five percent level, although the coefficient of the parcel size variable is significant only at the 20 percent level. However, the size variable was left in the equation since this measure was shown to be relatively significant in other estimated equations, and does have conceptual validity. The signs are all positive as expected.

Using Equation 1, the land comparison technique was employed to isolate land price differences which stemmed from the floodplain/off-floodplain location difference. For all sales the estimated difference due to floodplain location was \$946, or an eight percent discount in the land price due to floodplain location. For the 100 year floodplain the discount was \$900, or nine percent, while in the 500 year floodplain, a \$903, or seven percent, discount was discovered. The basis for these figures can be found in Apendix Tables A-1, A-2, and A-3.[2]

Equation 2 was estimated to examine the possibility that flood risk could help explain variations in sale prices of parcels within the floodplain.

$$
\begin{array}{lllll}
Y = -1766 + & 104.73\,(X_1) + & 2.09\,(X_2) - & .23\,(X_3) + & 1.79\,(X_4) \\
 & t = 2.87 & t = 13.07 & t = 1.07 & t = .46 \\
 & \alpha = .0025 & \alpha = .0025 & \alpha = .10 & \alpha = .20
\end{array}
\qquad [2]
$$

$\overline{R}^2$ = .82
$\overline{Y}$ = 11109
n = 59
Sy = 2254
D.W.= 2.00

where:

Y = nominal sale price of residential parcels;
$X_1$ = year of the sale;
$X_2$ = assessed value of improvements;

[2]The apparent inconsistency of a \$946 discount for all sales and a \$900 and \$903 discount for sale in the 100 and 500-year floodplains respectively is explained by the use of average values where the size of the two samples is different.

$X_3$ = size of the parcel; and,

$X_4$ = flooding measure as discussed in Section III.

The $\overline{R}^2$ value is satisfactory. The coefficients of the year of the sale variable and the assessed value of improvements variable are significant at the five percent level. The coefficients of the size of the parcel and the flooding variables are significant only at the 10 percent or 20 percent levels respectively. The size variable carries an unexpected negative sign; however, this is not of major concern since the coefficient is relatively insignificant. Of interest is that the flood risk variable was relatively insignificant. Given the apparent discount in land prices for floodplain location found using the land comparison method, this result seemed somewhat surprising.

One possible explanation for the insignificance of the flood risk proxy is that 60 percent of the floodplain sales observations were in the 500 year flood area where the flood risk is not as intense as in the 100 year flood area. Also, flooding in the Roanoke area has been a rather infrequent event since 1945 when the observations began. Thus, the influence of the flood proxy on year to year sale variations may not be significant, even though prices overall on the floodplain appear to be discounted for flood risk.

To examine the possibility that flood risk may not be affecting land sale price, a questionnaire was administered to current Wasena Park residents. The results indicated that the current homeowners have a limited perception of flood risk. Ninety percent did not think their property had flooding problems before they purchased it. When asked how frequently flooding occurred in their area, 70 percent said never, 10 percent said every 20 years and 20 percent said every three years. All respondents argued that flooding potential did not influence their location choice.

B. South Roanoke Park Area

The result of the regression analysis for flood-free sales is shown in Equation 3.

$$
\begin{array}{llll}
Y = -1984 + & 169.4\,(X_1) + & 1.27\,(X_2) - & .31\,(X_3) \\
 & t = 4.98 & t = 3.02 & t = .37 \\
 & \alpha = .0025 & \alpha = .0025 & \alpha = .30
\end{array}
\qquad [3]
$$

$\overline{R}^2$ = .57

$\overline{Y}$ = 10127

n = 50

Sy = 2190

D.W. = 1.75

where:

$Y$ = nominal sale price of residential parcels

$X_1$ = year of sale

$X_2$ = assessed value of improvements at time of sale

$X_3$ = size of parcel

The coefficients of the year of sale and value of improvement variables are significant. The size of variable is not significant.

For all floodplain sales a $1,030 difference due to floodplain location was found. In the 100 year floodplain this difference was estimated at $1,300 while in the 500 year floodplain it fell to $314. Appendix Tables A-4, A-5, A-6 summarize these results. Thus there appears to be a difference in land price due to floodplain location, although the low $\overline{R}^2$ value of the prediction equation suggests that the numerical estimates of this difference may have broad confidence intervals.

Equation 4 was used to see if variations in flood risk could help explain variations in land sale prices within the floodplain.

$$Y = -13472 + \underset{\substack{t = 4.10 \\ \alpha = .0025}}{276.99\,(X_1)} + \underset{\substack{t = 1.37 \\ \alpha = .05}}{.99\,(X_2)} + \underset{\substack{t = 1.1 \\ \alpha = .10}}{.37\,(X_3)} + \underset{\substack{t = .2 \\ \alpha = .40}}{1.58\,(X_4)} \qquad [4]$$

$\overline{R}^2$ = .35
$\overline{Y}$ = 8946
n = 50
Sy = 3361
D.W. = 1.48

where:

$Y$ = nominal sale price of residential parcels
$X_1$ = year of the sale
$X_2$ = assessed value of the improvements
$X_3$ = size of the parcel
$X_4$ = flooding measure as discussed in Section III

The $\overline{R}^2$ is quite low.[3] The coefficients of the year of sale and the value of improvements have the expected sign and are significant at the five percent level. The parcel size variable is significant at the 10 percent level. The flooding variable is clearly an insignificant explainer of price.

The insignificance of the flooding variable, and the low $\overline{R}^2$ for the equation as a whole, were furthered examined by interviewing current residents of South Park. Seventy percent of the homowners did not think their property had flooding problems before they purchased it, and all land owners in the 500 year floodplain held this opinion. When asked how frequently flooding occurred in the area, 50 percent said less than every 20 years, while the remainder felt that flooding could occur more frequently. All 500 year floodplain homeowners said "never." Only 10 percent of the respondents considered flood potential in making their location choice. This vari-

[3] When the sale observations were split between the 100-year and 500-year floodplain, no significant improvement was realized.

ability in response may help explain the unsatisfactory explanatory power of the floodplain equation.

In summary, both the Roanoke case studies suggest that floodplain location negatively influences land values. However, within the floodplain, variables used to represent the pattern of river flows do not generally help explain such sale price variation. This may be so, since many of the floodplain occupants apparently do not recognize patterns of flood risk in the area.

### II. The Radford Case Study

In 1947 Claytor Lake Dam's construction was completed and flooding was substantially eleminated in what was the Radford 100-year floodplain. To evaluate the influence of Claytor Lake Dam on sale prices, a regression equation was estimated using all floodplain sales between 1931 and 1974.[4] The results are shown in Equation 5.

$$Y = -714 + \underset{\substack{t\,=\,4.23 \\ \alpha\,=\,.0025}}{1.76\,(X_1)} + \underset{\substack{t\,=\,3.87 \\ \alpha\,=\,.0025}}{.11\,(X_2)} + \underset{\substack{t\,=\,1.11 \\ \alpha\,=\,.10}}{439.34\,(X_3)} \qquad [5]$$

$\overline{R}^2 = .80$
$\overline{Y} = 1838$
$n = 25$
$Sy = 793$
$D.W. = 1.68$

where:

$Y$ = sale price of residential parcels in constant 1967 dollars;
$X_1$ = assessed value of improvements at time of sale in constant 1967 dollars;
$X_2$ = size of the parcel; and,
$X_3$ = dummy variable representing the time during which Claytor Lake Dam was in place. All years prior to 1947 = 0 and 1947 and after = 1.

The policy variable represents the policy action (a dam), but also incorporates the elimination of flooding as a problem in the area. The coefficient of the assessed value of improvements and the size of the parcel variables are statistically significant at the five percent level. The coefficient of the dummy variable representing the time during which Claytor Lake Dam was in place is significant at the 10 percent level. The signs are all positive as expected and suggest, in particular, that construction at Claytor Lake Dam appears to have had a positive effect on property values. That is, the

4 In order to overcome multicollinearity problems between a variable representing year of sale and the dummy variable the dependent variable was adjusted to 1967 dollars using the national housing cost index. This adjustment helps account for changes in housing demand and supply characteristics that could influence market prices, and are not accounted for in the equation. However, it is not as satisfactory as a time trend variable would be since it is a national rather than local price index.

existence of the flood risk reduced property values, and conversely, the dam had a positive influence on property values.

Although the level of significance is not entirely satisfactory, the coefficient of the dummy variable was used to place a dollar value on the effect of Claytor Lake Dam. This coefficient suggests that $439 (in 1967 dollars) was added to the price of an average lot by the Claytor Lake Dam.

The land comparison method was also employed to isolate the influence of Claytor Lake Dam. Unlike the Roanoke cases, a flood-free control area was not utilized. Rather, sales in the floodplain before the dam were compared to sales after the dam. Equation 6 which was estimated using sales prior to 1947, was used to predict a post-1947 average price which would have occurred without the dam in place.

$$\begin{array}{llll} Y = -1199 + & .07\,(X_1) + & 1.5\,(X_2) + & 17.6\,(X_3) \\ & t = 8.8 & t = 7.19 & t = 1.75 \\ & \alpha = .0025 & \alpha = .0025 & \alpha = .05 \end{array} \qquad [6]$$

$$\begin{aligned} \bar{R}^2 &= .91 \\ \bar{Y} &= 655 \\ n &= 14 \\ Sy &= 216 \\ D.W. &= 1.94 \end{aligned}$$

where:

$Y$ = nominal sale price of residential parcels;
$X_1$ = size of the parcel;
$X_2$ = assessed value of improvements at time of sale; and,
$X_3$ = year of the sale.

When compared to actual average sale price during the post-1947 period using the land comparison technique, an estimated $450 nominal price difference attributable to the dam was found. Appendix Table A-7 summarizes this result.

The two approaches used here to examine the influence of Claytor Lake Dam show consistent results. The findings suggest that if Claytor Lake Dam had not been constructed, residential property values in the study area would have been lower than those that now exist.[5]

**III. The Alexandria Case Study**

The flooding problem in the Alexandria area along the Four Mile Run has become increasing severe since 1963. In 1970, a zoning ordinance went into effect designed

[5] A control area outside the floodplain was also studied. The specific results need not be reported here, however, the general finding was that land prices in the floodplain increased much more rapidly after the construction of the dam, than did those in the control area.

to restrict development in the 100-year floodplain. Simultaneously, the current homeowners of the flood-prone area qualified for federally subsidized flood insurance. The influence of increased flood risk and this zoning measure were the focus of study.

First a regression equation was estimated incorporating a dummy variable representing the time period during which floodplain zoning was in effect (Equation 7).

$$
\begin{array}{llllll}
Y = & -920 + .29\,(X_1) & + 281.72\,(X_2) & - 184.32\,(X_3) & + 579.22\,(X_4) & \\
 & \quad t = 1.96 & t = 8.33 & t = .48 & t = 1.71 & \\
 & \quad \alpha = .025 & \alpha = .0025 & \alpha = .20 & \alpha = .025 & \\
 & + 2.13\,(X_5) & - 6.73\,(X_6) & & & [7] \\
 & \quad t = 3.53 & t = 3.78 & & & \\
 & \quad \alpha = .0025 & \alpha = .0025 & & &
\end{array}
$$

$\overline{R}^2$ = .45;
$\overline{Y}$ = 13539;
n = 222;
Sy = 1706; and,
D.W. = 1.67.

Where:

$Y$ = nominal sale price;
$X_1$ = size of the parcel;
$X_2$ = year of the sale;
$X_3$ = dummy variable representing the existence of restrictive zoning in the floodplain; all years prior to 1970 = 0, and 1970 to 1974 = 1;
$X_4$ = dummy variable indicating corner location (1) and otherwise (0);
$X_5$ = assessed value of improvements at time of sale; and,
$X_6$ = flooding measure as described in Section III.

The measure of flood potential was included, since flood potential continued to exist with the zoning policy in effect. Also it should be noted that after the adoption of restrictive zoning, subsidized flood insurance became available and the flood of record also occurred. Thus, all these influences may all be picked up by the dummy variable representing the time period during which the zoning was in effect.

All the estimated coefficients in Equation 7 have the expected sign, and with the exception of the dummy variable indicating the existence of restrictive zoning, are significant at the five percent level. The zoning variable is a relatively insignificant explainer of price variation. Thus based on this equation, the hypothesis was rejected that price significantly differed between floodplain parcels sold before and those sold after changes in the zoning ordinance went into effect. It should be noted, however, that the $\overline{R}^2$ value is quite low, which suggests a great deal of unexplained variation in land sale prices.

The land comparison technique was then employed in hope of isolating the influence of zoning. Determinants of prices for 146 sales on the floodplain before 1970 were evaluated using regression techniques. It was intended that this would then be useful for prediction of post-1970 prices for application of the land comparison method (Equation 8). However, an unsatisfactory $\overline{R}^2$ of .32 precluded use of the estimated equation for prediction.

$$Y = 4600 + \underset{\substack{t = 7.37 \\ \alpha = .0025}}{343.21\,(X_1)} + \underset{\substack{t = 2.99 \\ \alpha = .0025}}{906.41\,(X_2)} + \underset{\substack{t = 1.61 \\ \alpha = .05}}{1.2\,(X_3)} - \underset{\substack{t = 2.28 \\ \alpha = .0125}}{4.56\,(X_4)} \qquad [8]$$

$\overline{R}^2$ = .32;
$\overline{Y}$ = 12802;
n = 147;
Sn = 1431;
D.W. = 169.

Where:

$Y$ = nominal sale price of residential parcels;
$X_1$ = year of the sale;
$X_2$ = dummy variable indicating corner location;
$X_3$ = assessed value of improvements; and,
$X_4$ = flooding measure as described in Section III.

No firm conclusion could be drawn about the influence of zoning on land sale prices. This lack of evidence on the zoning effect is consistent with the answers to the questionaire administered to residents. Fifty percent of the homeowners questioned did not know if there was a zoning ordinance concerning flooding in effect at the time they purchased the property. In addition, 83 percent of the homeowners questioned indicated that they had purchased subsidized flood insurance, the availability of which would counteract the negative influence of zoning on price. A further explanation for the weak results obtained may lie in the variability of the perception of flood risk among owners. While a substantial percent now felt that their property had flooding problems (only 25 percent felt their property was unlikely to be flooded), 60 percent did not realize the flood potential at the time of purchase. While this suggests a higher level of flood risk recognition overall than in Roanoke, and may explain the significance of the flood variable in Equation 7, the low $\overline{R}^2$ value of Equation 7 may be explained by the variation among resident's perceptions of flood risk.

Being unable to use the land comparison technique using pre-1970 sales as a standard of comparison, land sales in a comparable flood-free area were used as a standard against which to compare sales of flood-prone land. The objective here was to examine the possibility that floodplain location will reduce such values, when compared to a flood-free area. Equation 9 uses flood-free area sales for the years 1960-1974.

$$Y = 4026 + 1068\,(X_1) + 704.4\,(X_2) + 2817.75\,(X_3) \qquad [9]$$

$$t = 5.46 \qquad t = 17.63 \qquad t = 4.83$$

$$\alpha = .0025 \qquad \alpha = .0025 \qquad \alpha = .0025$$

$\overline{R}^2$ = .72;
$\overline{Y}$ = 14609;
n = 144;
Sy = 1960;
D.W.= 1.83.

Where:

$Y$ = nominal sale price of residential parcels;
$X_1$ = ratio of the assessed value of improvements by the assessed value of the parcel;[6]
$X_2$ = year of the sale; and,
$X_3$ = dummy variable indicating corner location (1) and otherwise (0).

The $\overline{R}^2$ is improved considerably when compared to that of Equations 7 or 8. One possible explanation for this improvement could be the absence of variability among homeowners in the perception of the flood hazard. All variables in the equation demonstrate significance at the five percent level and have the expected signs. Using the coefficients developed for the non-floodplain area (Equation 9) and the average values over all sales for the floodplain variable, a $3,868 difference (22 percent) in average price of flood-prone lots compared to the flood-free area was estimated for 1960-1974. However, the dollar difference computed will combine flooding and zoning effects from 1970 forward, since the zoning ordinance and some flooding problems coincided in time. Subsidized flood insurance effects will also be present from 1970 on.

In an attempt to isolate the zoning and flooding effects, the land comparison method was applied on a periodic basis. Differences between predicted and actual floodplain sale prices were computed by periods between floods. Differences in land prices before 1970 were attributed to flooding alone, while differences after 1970 were attributed to flood risk, zoning and insurance effects together.

Table 2 presents the results of this analysis, together with the history of flooding in the area. Periods of relevance for the land comparison analysis are defined as time

[6]The use of the ratio $X_1$ instead of actual assessed value of improvements was necessary to overcome a bias in the assessed process in Alexandria. On parcels subject to flooding, both improvements and the land parcel itself are assessed lower than comparable flood-free parcels elsewhere. Thus, to use assessed value of improvements as a measure of value of improvements would bias the results since all parcels in the floodplain would have lower assessed values, although market replacement value would be equal. If it is assumed that the assessors discount both land and improvements by a consistent amount when properties are subject to flooding, the ratio of assessed values on comparable properties in both the flood-prone and flood-free areas should be more comparable than just the assessed value of improvements alone.

TABLE 2

**Yearly Percent Discount in Land Sale Price Due to Flood Risk Along the Four Mile Run**

| (1) Period | (2) Parcels Sold | (3) Predicted Value | (4) Observed Value | (5) Average Discount | (6) Discount as percent of prediction |
|---|---|---|---|---|---|
| 26 Aug 61–20 Aug 63 | 44 | 13,721 | 12,050 | 1,671 | 12.2 |
| 21 Aug 63–13 May 64* | 14 | 14,571 | 12,243 | 2,328 | 15.9 |
| 14 May 64–7 Oct 65 | 18 | 15,141 | 12,459 | 2,682 | 17.7 |
| 8 Oct 65–14 Sept 66 | 10 | 16,374 | 12,251 | 4,123 | 25.2 |
| 15 Sept 66–24 Aug 67 | 5 | 17,510 | 13,660 | 3,850 | 21.9 |
| 25 Aug 67-27 Jun 68 | 11 | 18,142 | 13,480 | 4,662 | 25.7 |
| 28 Jun 68–22 Jul 69 | 16 | 18,770 | 13,658 | 5,112 | 27.2 |
| 23 Jul 69–9 Jul 70* | 23 | 18,800 | 14,070 | 4,726 | 25.1 |
| 10 Jul 70–29 Jul 71** | 23 | 19,553 | 14,117 | 5,436 | 27.8 |
| 30 Jul 71–22 Jun 72** | 9 | 13,272 | 13,272 | 7,406 | 35.8 |
| 23 Jun 72–1974*,** | 45 | 21,139 | 16,727 | 4,412 | 20.9 |

*Indicates major flood.
**Zoning policies in effect.

elapsed between floods (column 1). The occurrence of major floods, as defined by the Army Engineers, is also indicated. Column 2 shows the number of sales for each period. Column 3 contains the predicted average sale price for each period for flood-prone lots, as if they were located in comparable flood-free areas, while column 4 represents the observed sales value of flood-prone lots.

For the first three periods, the discount as percentage of the predicted sale value is the lowest, although there is a stable increase (12-18 percent). From the flood of October 7, 1965 to July 30, 1971, the percentage increased and then fluctuated between 21 and 27 percent. The estimated discount of 36 percent for the period July 29, 1971 to June 22, 1972 is probably due to the small number of land sales observed. Unfortunately for analytical purposes, around 1970 the zoning ordinance was put in force, along with flood insurance, and presumably worked in combination with the major flood of June 23, 1972 to influence land prices. However, there was no explicit indication in the results of the influence each had separately.

**IV. Summary of Results**

The goal was to determine the impact of alternative flood-hazard reduction policies upon residential property values. The problem was conceptualized in a land-rent theory framework and multiple regression procedures were used to empiricize the theoretical arguments.

The empirical research was divided into three major areas of investigation. The general hypothesis that flood hazards have an effect on residential land prices was tested in all major areas selected. The Roanoke study was used to test the hypothesis that a reduction in land values is related to the potential for flooding. The case study conducted in Radford was used to test the hypothesis that structural flood control measures would enhance the value of previously flood-prone land. The case study of Alexandria was used to test whether land-use control measures would reduce the value of land beyond the reduction due to the flooding potential.

The sale price of flood-prone lands proved to be lower than the sale price of land in comparable residential areas. In addition the sale price of flood-prone land was enhanced due to the construction of the Claytor Lake Dam, a structural measure. Where there was a variability in flooding risk occurrances over time, a variable to measure flood potential helped explain land price movements within the floodplain in at least one study area. However, no sufficient empirical evidence was found to indicate that restrictive land use control measures reduce the sale value of flood-prone land.

# SECTION V
# DISCUSSION

## I. Critique of Procedures

A change in land price due to differing levels of flood hazard is a comprehensive measure when measured by a dummy variable in a single multiple regression equation or by the land comparison method. The use of a dummy variable to represent the time when a flood hazard policy went into effect may incorporate other factors which occurred simultaneously with the policy. Similarly, the use of the land comparison technique may suffer from the same problem when observations on sale price are divided according to the time the policy went into effect.

When flood-free and flood-prone locations are compared, the result will identify differences in price due to flood potential. However, other factors may also bear on the calculated difference and cannot be controlled for by regression techniques. First, various natural amenities which characterize the floodplain area may be foreign to the flood-free area and may be unaccounted for by control variables included in the model. These characteristics could include, as disamenities, increased humidity or smell of still waters, or the amenity of having waterfront property. Also, topographic factors may be relevant influences on location price differences. By definition, the floodplain and the flood-free areas cannot be absolutely comparable as far as topography is concerned, because the boundaries between the adjacent flood hazard and flood-free areas are always drawn where flat land begins to rise at a slope and becomes rolling and elevated.

In short, the differences attributed to flood risk as measured in this study may not be pure measures representing flood hazard alone, but rather represent differences attributable to either floodplain location or time periods. A major part of these estimated differences undoubtedly reflects flood hazard.

Given these qualifying comments on the methods used, the results appeared to indicate that location in the floodplain was negatively reflected on the sale price of land. However, one criticism of this conclusion is the apparent variable perception and understanding of flood risk that characterizes floodplain purchasers in this study, suggesting that a lower price for floodplain parcels should not necessarily be expected. However, some of the buyers of residential parcels in floodplains are aware of the hazard, and do offer a lower price for flood-prone real estate, while others, being unaware of the risk or putting a low value on such risk, are willing to pay a higher price. Still, this need not suggest that the land market cannot accurately account for flood hazard. If a significant number of floodplain occupants take flood risk into account, they may affect the market for such land by offering lower prices at the margin. Thus, lower equilibrium prices for flood-prone land may be observed because potential buyers who were *unaware* of the flood risk were not willing to pay more for their homes when they knew that comparable pieces of real estate in the floodplain sold for less. Location factors directly related to flooding, therefore, can depress prices in the floodplain and may compensate, in part, for information failure on the part of some buyers.

## II. Conclusions

The construction of Claytor Lake Dam apparently enhanced property values. This implies that the private landowner may indeed have an incentive to promote structural flood control measures in the political process. Also, the generally lower value of flood-prone property further adds to this argument that floodplain occupants may have a reasonable incentive to act in the political process for selection of structural measures which add to the property values.

The fact that analytic procedures did not isolate a negative effect on sale price for a restrictive zoning policy need not imply that owners of flood-prone property would not bother to oppose such policies. Rather, this result may stem from conditions unique to this study. One such condition is the apparent variability in the perception of policies toward flood hazard. The Alexandria questionnaire did demonstrate individual ignorance of the existence of zoning policies. Another possible reason why zoning policies appeared insignificant is the level of development characterizing the case study examined. The Alexandria study area was highly developed and changes in the zoning ordinance may not actually impose severe building or similar restrictions upon property of residential real estate owners. An ideal area for study would be one which would be completely undeveloped or a residential area with many vacant parcels. Restrictive zoning policies could best be reflected in land values of residential parcels in such areas. Apparently zoning restrictions in the Four Mile Run area in Alexandria were designed to affect empty space (such as marsh), which may have potential for attracting either new commercial or multiple family residential units. Such lands may have been significantly affected by zoning restrictions; however, investigation of nonsingle-family residential land was beyond the scope of this research effort.

A third possible reason for the inconclusive results of the restrictive zoning measure might be the possible adoption of optimum zoning policies. Zoning restrictions may not have decreased the value of land beyond the functioning of the land market. Zoning restrictions are needed when the market fails to reflect the flood hazard in land values, due to lack of information, for example (see Section II). In a situation where the market mechanism is operating reasonably well, land values are depressed due to the flood risk, and zoning restrictions may have no influence. Lastly, the interaction of the several effects of zoning, flood potential, and subsidized flood insurance comprises another reason why it was empirically difficult to isolate zoning-restriction effects using the methods of this study.

The identification of policy actions based on these relatively weak results may not be in order. However, enough tendencies in land prices which fail to refute this study's general hypotheses are present to suggest that policies of taxation or subsidies might be investigated which would motivate political choice behavior toward selection of efficient policies toward flood hazard. Still, several notes of caution are suggested by these results. For example, it may appear that a tax equal to damages to be prevented should be imposed on residents of the floodplain if a structural measure were to be adopted. The willingness to pay for such measures by floodplain landowners, however, may be different from actual damage-prevented figures. If increases in land sale prices to be gained by the measure will be less than the present value of damages prevented, individuals may be unwilling to pay a tax equal to damage-prevention even if the structural measure is the most efficient solution.

With regard to zoning measures, it may appear that a subsidy is in order to enhance the inclination of people to support such policies. The inconclusive results of the analysis of zoning measures make implications for subsidy policies difficult to draw. However, as with structural measures, a general conclusion is that such subsidies might be tied to land prices as opposed to expected flood damages computed through traditional engineering cost approaches.

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# APPENDIX A
# TABLES A-1—A-8

**TABLE A-1**

**Average Price per Lot Analysis for Comparing the Flood-Free and the Entire Floodplain Areas of Wasena Park in Roanoke**

| | |
|---|---|
| 1. Average price, 74 flood-free parcels | $11,128 |
| 2. Average price, 59 floodplain parcels | 11,109 |
| 3. Unadjusted difference | 19 |
| 4. Estimated price of flood-prone parcels in flood-free area | 12,055 |
| 5. Difference due to the floodplain location | –946 |

**TABLE A-2**

**Average Price per Lot Analysis for Comparing the Flood-Free and the 100 Year Floodplain Area of Wasena Park in Roanoke**

| | |
|---|---|
| 1. Average price, 74 flood-free parcels | $11,128 |
| 2. Average price, 23 intermediate regional floodplain parcels | 9,250 |
| 3. Unadjusted difference | 1,878 |
| 4. Estimated Price of floodprone parcels in flood-free area | 10,150 |
| 5. Difference due to the floodplain location | –900 |

**TABLE A-3**

**Average Price per Lot Analysis for Comparing the Flood-Free and the 500 Year Floodplain Area of Wasena Park in Roanoke**

| | |
|---|---|
| 1. Average price, 74 flood-free parcels | $11,128 |
| 2. Average price, 36 standard project floodplain parcels | 12,297 |
| 3. Unadjusted difference | –1169 |
| 4. Estimated price of flood-prone parcels in flood-free area | 12,300 |
| 5. Difference due to the floodplain location | –903 |

## TABLE A-4

**Average Price per Lot Analysis for Comparing the Flood-Free and the Entire Floodplain Areas of South Roanoke Park Area**

| | |
|---|---|
| 1. Average price, 50 flood-free parcels | $10,127 |
| 2. Average price, 50 floodplain parcels | 8,946 |
| 3. Unadjusted difference | 1,181 |
| 4. Estimated price of flood-prone parcels in flood-free area | 9,976 |
| 5. Difference due to floodplain location | 1,030 |

## TABLE A-5

**Average Price per Lot Analysis for Comparing the Flood-Free and the 100 Year Floodplain Areas of South Roanoke Park Area**

| | |
|---|---|
| 1. Average price, 50 flood-free parcels | $10,127 |
| 2. Average price, 39 intermediate regional floodplain parcels | 8,961 |
| 3. Unadjusted difference | 1,166 |
| 4. Estimated price of flood-prone parcels in flood-free area | 10,291 |
| 5. Difference due to floodplain location | 1,330 |

## TABLE A-6

**Average Price per Lot Analysis for Comparing the Flood-Free and the 500 Year Floodplain Areas of South Roanoke Park Area**

| | |
|---|---|
| 1. Average price, 50 flood-free parcels | $10,127 |
| 2. Average price, 11 standard project floodplain parcels | 8,891 |
| 3. Unadjusted differences | 1,236 |
| 4. Estimated price of flood-prone parcels in flood-free areas | 9,205 |
| 5. Difference due to the floodplain location | 314 |

## TABLE A-7

**Average Price per Lot Analysis of the Flood Area for Comparing the Before and After Periods of the Construction of the Claytor Lake Dam**

| | |
|---|---|
| 1. Average price, 11 floodplain lots sold after the construction of the dam | $2,461 |
| 2. Average price, 14 floodplain lots sold before the construction of the dam | 655 |
| 3. Unadjusted difference | 1,806 |
| 4. Predicted price of lots sold "after" 1947 if dam had not been built | 2,011 |
| 5. Difference attributable to the influence of the dam | 450 |

## TABLE A-8

**Average Price per Lot Analysis for Comparing the Flood-Free and the Floodplain Area in Alexandria**

| | |
|---|---|
| 1. Average sale price of 144 flood-free lots | $14,609 |
| 2. Average sale price of 22 floodprone lots | 13,539 |
| 3. Unadjusted difference | 1,070 |
| 4. Estimated price of flood-prone parcels in flood-free area | 17,407 |
| 5. Difference due to the floodplain location | 3,868 |

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