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Benefit of Water Pollution Control On Property Values

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Benefit of Water Pollution Control on Property Values

By

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Abstract

This study was undertaken to determine the current state-of-knowledge concerning the measurement of the potential benefit of water pollution control on property values, and to analyze the relationship between water quality parameters and property values at several sites where water pollution has been substantially reduced in recent years. Multiple-regression analysis and an interview technique were employed to study the relationship between residential and recreational property values and water quality components. Study sites were located on San Diego Bay and the Kanawha, Ohio, and Willamette Rivers. It was found that effective pollution abatement on badly polluted water bodies can increase the value of single-family homes situated on waterfront lots by 8 to 25 percent, and that these water quality improvements can affect property values up to 4000 feet away from the water's edge. It was also found that the measurable water quality parameters which have the greatest influence on property values are dissolved oxygen concentration, fecal coliform concentrations, clarity, visual pollutants (trash and debris), toxic chemicals, and pH.

Case study results were combined with a 1971 Environmental Protection Agency water pollution survey to estimate the national benefit expressed in increased residential, recreational and rural waterfront property values, to be gained from water pollution abatement. The estimated capital value of the benefit ranges from .6 to 3.1 billion dollars, with a most likely benefit of 1.3 billion dollars.

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Section I

Conclusions

1. A substantial water quality improvement in a badly polluted water body will increase the value of nearby urban residential property. The pollution abatement benefit for each residence can be expressed as a percentage of the original property value. The maximum percentage increase occurs at the waterfront and the benefit decreases inversely with distance from the water. The extent of the water quality influence depends on the presence or absence of obstacles between residences and the water, but benefits can be obtained up to 4000 feet from the water body. This study measured pollution abatement benefits of from 3 to 25 percent for single-family waterfront residences.

2. The value of rural land suitable for development near a large water body is also increased by water pollution abatement. This study observed increases attributable to pollution abatement of from 65 to 100 percent for waterfront land on the Willamette River near Portland, Oregon.

3. This study found that residential property owners generally value the wildlife support capacity of natural water resources more than either aesthetics or boating and swimming potential. The measurable water quality parameters which have the greatest influence on property values were found to be dissolved oxygen, fecal coliforms, clarity, trash and debris (visual pollutants), toxic chemicals, and pH. The feasibility of correcting those pollution components which are of greatest importance to residential property owners, and therefore of realizing benefits in property value increase, is very good.

4. Our results indicated that abatement of pollution in all waters in the nation to levels which are not inhibiting to desirable life forms or practical uses and which are aesthetically agreeable would increase the total capital value of existing residential and recreational property from .6 to 3.1 billion dollars. The most likely increase would be 1.3 billion dollars. The annualized value of 1.3 billion dollars is 76 million dollars, using a 6 percent discount rate. About 59 percent of the total increase would occur in towns of from 1000 to 1,000,000 population; 31 percent would

accrue to large metropolitan areas: and property value increases in rural areas would account for the remaining 10 percent.

Although 40 percent of the nation's people live in metropolitan areas of greater than one million population where property values are highest, these areas receive only 31 percent of the benefit. This is explained in part by the fact that industry and commerce. rather than homes and parks, occupy most of the land adjacent to badly polluted water in these areas.

Section II

Introduction

Increases in the value of properties adjacent to rivers, lakes, and bays represent one of the benefits of water pollution abatement. Our objective in this study has been to measure this benefit. In the course of achieving this objective, we accomplished tasks which are described in detail in this report:

1) We completed a review of the literature on the current state-of-knowledge concerning the potential benefit of water pollution control on property values.

2) We undertook specific case study analyses in several areas where a significant change in water quality had taken place in order to determine the magnitude of the property value impact, the importance of specific components of water quality in people's valuation of water resources, and the relation between property values and water quality. We focussed on residential and recreational properties in metropolitan areas and towns, and on all waterfront properties in rural areas.

3) Using national figures for the amount of stream and lake shoreline exposed to polluted water, and the magnitude of the impact measured at our case study sites, we estimated the benefit to the nation in terms of increased residential and recreational property values which would result from nationwide water pollution abatement.

Property value is a valid and important reflector of the value of improvements to a natural resource such as water quality improvements. If people consider a stream or lake to be an amenity, they will be willing to pay more to live near it. The amount people are willing to pay will thus be reflected in the market value of houses and land located near the water. However, if the water is badly polluted, it ceases to represent an amenity to nearby property owners, and consequently the value of properties near the water will decrease. As the water quality subsequently improves, nearby property values will increase accordingly to reflect the water body's value as an amenity. The water pollution abatement will produce the greatest benefit to owners of properties located at the water's edge, while at some distance away, the water quality improvements will have no measurable effect.

Multiple-regression analysis was used to isolate the influence of the change in water quality from all of the other influences affecting property value changes during the time period studied at the case sites. Multiple-regression analysis offers a proven and widely accepted method for apportioning the total variation in a variable to the various influences which combine to produce that variation. The explanation of property value changes is one frequent application of the multiple-regression technique. Since the influence of water quality improvements on surrounding property values varies with the properties' distances from the water body, we were able to refine the technique to isolate that portion of total property value change which is associated with changes in water quality by including distance from the water in our regression equations. In the absence of other influences which vary with distance from the water resource, it is reasonable to attribute to water quality changes that portion of the variation in property value which is highly correlated with distance from the water. With this method, we can determine how rapidly water quality improvement effects decrease with distance from the water as well as the magnitude of the impacts. This refinement allowed us to estimate the national property value benefit attainable from water pollution abatement with a greater degree of precision than would have been possible had we not been able to assess the decrease of benefits impact with distance from the water.

When applying the regression technique to isolate water quality influences, particular care must be taken to account for any other property value influence which might vary colinearly with distance to the water body and thus be confused with the water quality influence. A new waterfront park would constitute an influence of this type. We deliberately selected our case study sites to avoid such colinear influences.

Our final selection of case study sites was the product of a nationwide search for water bodies with documented water quality changes. Five major water bodies were located which had experienced significant and well-documented water quality improvements between 1960 and 1970. The water bodies were San Diego Bay, the Willamette River in Oregon, the Kanawha River in West Virginia, the Ohio River in Pennsylvania, and Lake Washington in Seattle, Washington. Seven areas adjacent to these water bodies were selected as case study sites to measure the influence which recent water pollution abatement had on surrounding property values. Six of these areas were urban or suburban, while one was rural.

Sales prices and calibrated local tax assessment values were used to measure the changes in the value of single-family residences and in recreational and rural waterfront land which occurred during the same time period as the water pollution abatement. We conducted our own sales ratio studies to compare local tax assessments with actual sales prices in order to validate the accuracies of assessed values as surrogate data where actual sales prices were not available for both of the years bounding the period of water quality change. We used only those assessed values which compared closely to actual sales prices.

We also designed a personal interview for administration to residential property owners in our study areas, to learn if they perceived the change in water quality, and how they ranked the relative importance of the wildlife support capacity, recreational potential and aesthetic aspects of all water resources. We also queried the relative importance of different measurable aesthetic water components in their total valuation of water quality. The interviews were conducted at the study sites by an experienced opinion research firm.

Although we did not develop a new water quality index, we did use the tabulated interview results to determine which water quality components - and hence, which pollutants - are the primary determinants of the property value impact. This result in turn applies to an estimation of which water pollution abatement efforts will produce the greatest property value benefit.

Our estimation of the national property value benefit obtainable through water pollution abatement efforts proceeded in several steps. First, we used the results of a 1971 United States Environmental Protection Agency water pollution survey using a pollution duration-intensity (DI) index, to locate polluted water reaches throughout the contiguous United States, and to establish the severity of the pollution of each. The amount and types of all discernible recreational and residential property adjacent to polluted water was measured on United States Geological Survey topographic maps.

Then we established a relationship between pollution levels as measured by the DI index and the potential increases in property values which would accrue from pollution abatement. The estimation of the relationship was based primarily on the case study results and our experience in other phases of the study.

Finally, we calculated the benefit in terms of an increase in property values nationwide which would be obtained if abatement efforts reduced the pollution level of all national waters to a DI factor of zero. (A DI level of zero implies pollution levels which are not inhibiting to desirable life forms and practical uses, and which are aesthetically agreeable.) We calculated low, medium and high estimates of the national benefit to account for the relative conservativeness of the assumptions upon which our measurements were made for different kinds of areas, the differing extent of inclusiveness of properties for which value changes were measured, and the different degrees of confidence supporting the ranges within which the actual national benefit can be expected to lie.

The body of this report consists of four main sections. Section II describes the methodology used to measure water quality influences on property values. Section III discusses the characteristics of the sites chosen for intensive study and the results of the regression analysis. Water quality and the results of the personal interviews to determine the evaluation of water quality aspects are discussed in Section IV. Section V describes the methodology and results of the national benefit calculation. The annotated bibliography which represents a review of the current state-of-knowledge on the potential benefits of water pollution control is contained in Appendix I.

Section III

Site Selection and Case Study Methodology

SITE SELECTION

Our first project step was the location of potential sites for intensive study. In order to maximize the effectiveness of our property benefits assessment methodology, the case study sites must meet several selection criteria. First, the study site should be located on a water body which has experienced a significant and well-documented change in water quality between 1960 and 1970. Any change in water quality which would be apparent to people living near the water or using the water for recreational purposes is considered significant. Good documentation is integral to meaningful study results, as well as useful in estimating the nationwide benefits of pollution abatement. The time period, 1960 to 1970, was selected to coincide with the collection of national census data. United States Census Bureau statistics were used to estimate coincidental changes in some socio-economic variables. A ten-year span was considered adequate for water quality influences to be reflected in property values.

In addition to water quality changes, the potential site should have a stable, relatively homogeneous area of residential and recreational property running from the water's edge back for a distance of at least 4,000 feet. The distance to the water from a particular property plays a major role in our regression analysis, and it is important to have as much variation in this variable as possible. However, our earlier studies have indicated that the impact of a water resource on property values is generally not significant beyond 4,000 feet from the shoreline [10].

It is also desirable for the potential sites to be clear of major obstructions, such as freeways or railways, between the water body and surrounding property. Such obstructions interfere with the resource's impact, and property value responses beyond these obstructions are usually non-existent.

Another desirable site characteristic is the presence of some water-oriented recreation property within or near the site. The presence of recreation property at the site enables us to study water quality influences on recreational land value as well as the role of recreational areas as interfaces between the water body and private property.

To estimate changes in property values over time requires recorded market values for the same property in or around the two years bounding the period of the change under study. Actual sales prices under stable conditions are the best reflection of owners' valuations of their properties. However, only a small fraction of all properties are sold in any one year. An even smaller fraction of all properties would have been sold both in the years around 1960, and then again in the years around 1970. Thus it is extremely unlikely that a sufficient number of properties at any one site would have been sold in both of those years (even allowing a year or two on each side of both years) to provide for valid results. To circumvent this primary data problem, assessed value data can be used instead of actual sales prices, to estimate the market value for one of the base years. Clearly, assessed values only represent an assessor's judgment of the property's market value. However, we have found that in some cases, the assessors' estimations reflect actual sales prices with remarkable accuracy. This is no coincidence, since frequently the assessors' formula is carefully developed on the basis of actual sales records and periodically checked to keep it up to date. Furthermore, assessed values can be verified and adjusted by using those sales prices which are available. Since it is integral that a good correlation exist between assessed property values and actual sales prices at any site where we intend to use assessed values to represent market prices. we compared assessed values with actual sales prices at our study sites prior to their use. The results of the sales price-assessed value correlation analysis for selected sites are included in Appendices A through F.

Bays, lakes, and river reaches where there might have been a significant change in water quality between 1960 and 1970, were first located through library research and telephone conversations with water resource researchers and managers. The U.S. Army Corps of Engineers, the U.S. Geological Survey, the U.S. Department of the Interior Office of Water Resources Research, and the Environmental Protection Agency (EPA), as well as many authorities in state governments and river basin commissions were contacted for potential site listings. Systematic coverage of the contiguous United States was accomplished by contacting the chief of the Surveillance and Analysis Branch of the EPA Office of Water Programs in each of the ten regional EPA offices. This effort yielded the names of over forty water bodies where there may have been significant pollution changes.

Persons in government or water management most familiar with the water quality at a potential site were located and contacted to verify the water quality changes, to determine the history of the changes, and to establish the location. quantity, and quality of the data documenting the changes. If water quality changes could be verified, the distribution and condition of real estate was then determined as completely as possible by telephone contacts and map study. The status and accessibility of local real estate sales and tax assessment data were also established as completely as possible by telephone.

Finally, trips were made to several water quality surveillance offices to examine actual water quality data in order to verify changes in pollution levels. Where water quality changes were significant and well-documented, field surveys were made to determine the distribution of private and public property, to examine the relationship between properties and the water body, and to gather preliminary sales and tax data.

A list of all of the water bodies which were investigated and then rejected as study sites follows this report in Appendix H. An examination of this list will reveal the extent of the site search.

Our investigation yielded seven sites situated on five different water bodies where there have been substantial, well-documented water quality changes since 1960, and where property characteristics and distribution meet our study criteria. The sites included two rivers in the eastern United States, and a river, an ocean bay, and a lake in the western states. Six sites are urban, and one is rural.

The water bodies finally selected for study were San Diego Bay in Southern California; the Willamette River in Oregon; Lake Washington in Seattle, Washington; the Ohio River in the vicinity of Pittsburgh, Pennsylvania; and the Kanawha River in West Virginia. Deliberate efforts to control pollution have measurably improved water quality in each of these water bodies since 1960. The nature of the improvements is discussed in Section III, and the water quality data is included in Appendices A through G.

The property value impact of water pollution abatement is a function both of the size and type of water body and of the type of development on its banks or shore. That is, the property value benefit may be greater for large lakes surrounded by recreation property, than for rivers, where residential properties are not the sole development. At the same time, the size and type of water body may influence the type of adjacent real estate development, and this relationship may differ for stream and river bank as opposed to lake and bay shore or ocean beach. (For example, it would seem inadvisable to develop massive industry on the shore of a small lake but very convenient to locate it along the banks of a large river). This relationship will even differ considerably between water bodies of the same type where local circumstances vary. Obvious factors which influence the relationship are differences in suitability for development, potential for alternative uses, local economic circumstances, and recreation opportunities.

In addition, where there are no developments or topographic obstructions, a tendency exists for higher-priced properties to locate on the shoreline, whatever the water body. Lower-priced properties adjacent to these may then realize a certain spill-over of benefits from the higher-priced homes. This effect can allow for the property value benefits from improved water quality to be felt by properties at greater distances from the water's edge than would otherwise be the case.

In selecting our case study sites, we tried to achieve as much variation as possible along water body types (including rivers, lakes, and bays) and geographic locations so that our results and the experience gained would be useful in extrapolating to estimate the national benefits of pollution abatement in all types of water bodies. Our nationwide survey was exhaustive for sites on water resources which could meet our selection criteria. The seven sites adjacent to five water bodies reported here are the only candidates nationwide which met our criteria for water quality conditions and documentation and for the physical developments at the site. It thus seems highly unlikely that a, study sample large enough to represent all water body types and site development criteria, as well as all water quality changes could be found to rigorously determine the differing impacts of different types of water resources. However, the preponderance of controllable water pollution nationwide occurs in rivers; thus the inclusion of three rivers in our sample renders our study particularly valuable for extrapolating the national property value benefit attainable through water pollution abatement.

On the basis of the criteria discussed above, seven sites adjacent to the water bodies were selected for intensive study. San Diego Bay, the Ohio River, the Willamette River, and Lake Washington each had one residential study area, while the Kanawha River had two. An additional area in the Willamette River Valley near Portland, Oregon, was selected to study the influence of water quality on rural land values. The sites are plotted on the map of Figure 1, while the detailed characteristics of each site are treated in Section III and Appendices A through G.

Occupying the entire west side of Lake Washington, Seattle, was a very appealing site because it offered enough residential properties which sold both in years near 1960 and again near 1970 for us to use only actual sales price data in the regression analysis. The dramatic water changes experienced in Lake Washington and the fact that this was the only lake site available, also rendered it a highly desirable site, in spite of the serious economic recession which upset the Seattle housing market in the late 1960's. Our attempts to correct for the effects of the recession on the housing market proved unsuccessful, and after poor preliminary results we rejected the Seattle site.

METHODOLOGY

The same general methodology was applied at every site. Initially, the study area boundaries were defined and all those physical factors within or near the site were identified which might affect property values differentially across the area colinearly with the water quality improvement. These factors included shopping centers, schools, major employers, growing commercial areas, new highways or bridges, and parks. The impact of any of these stationary influences on surrounding property values tends to depend on their line of sight distance or shortest access route from the property to the influence object.

Changes in non-stationary variables which might affect property values were also investigated, including zoning changes, changes in city services, such as sewers or water, changes in housing density, and changes in racial composition.

Zoning changes were determined from maps in city or county planning offices. We controlled for the effects of rezoning by eliminating from our study any area or parcel of land which had been rezoned since 1960. No major rezoning programs had been undertaken at any of the study sites. There were also no changes in city services or major street improvements within the boundaries of any of our case sites during the period

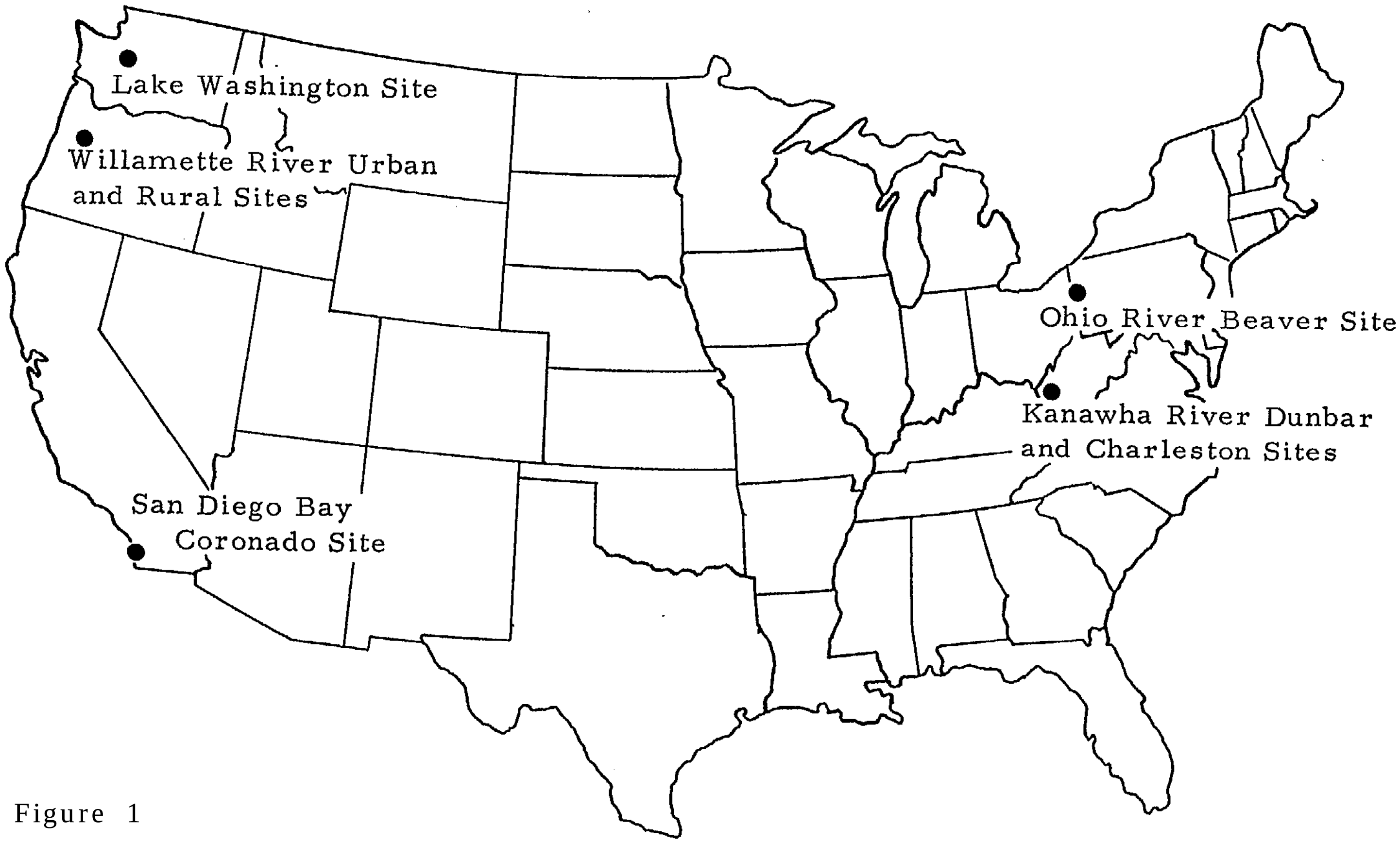

Figure 1

SITE LOCATIONS

studied. This kind of stability is one major advantage of selecting sites in well established, developed neighborhoods.

As mentioned earlier, the years 1960 and 1970 were chosen as base years to study property value changes. Water quality improvements at all sites took place during the 1960's, and the time span selected allowed Census data to be used to measure changes in housing density, population, and racial composition.

Sales prices were used at all sites to estimate market value at one extreme of the time span, while tax assessment valuations were used at the other (with the single exception of the Seattle site). Thus, the change in market value of any particular property was generally approximated by the difference between a sales price and an assessed value.

The local tax assessments used in this study were all tested by comparing a large sample of house sales prices with the assessed value of the same property at the time of the sale. Only data from good assessments were used as substitutes for market value and a correction factor based on actual sales prices was always applied to assessed values to correct any consistent bias.

Sales price data was collected from public tax records or deeds. We made every effort to select only those sales which might represent the true market value of a particular piece of property. Sales between members of the same family or sales of estate property were discarded, as were all sales where there was a large discrepancy between a sales price and the assessed value of the property at the time of sale. In some cases the sales price appearing on a deed or other public record is misleading, and an accurate interpretation of the recorded sales price figure requires information about such things as financing arrangements, and other property transactions between buyer and seller. However, misrepresentative sales prices can usually be detected by reading the terminology of the deed or by comparing sales price to assessed value at the time of the sale. We were able to detect and discard misleading data by following these procedures.

The property value change for the period studied was calculated by adding the capitalized value of property tax changes to the estimated change in sales or market value. The purchaser of a parcel of property assumes, in addition to his property rights. the responsibility for paying property taxes into the indefinite future. Thus, the real market value of the property, what the buyer really pays, is the total sales price of the property plus an indefinite number of tax payments. These taxes must be accounted for in our analysis because they directly affect the sales prices we observe, while increased tax revenues constitute another benefit attributable to improved water quality [4].

A discount rate of 10 percent was used to calculate the capitalized or present value of the tax change. All 1960 values, sales prices and taxes, were inflated to 1970 dollar values using the Consumer Price Index. Capitalized values of taxes, using the 10 percent discount rate, averaged about 30 percent of sales prices.

REGRESSION MODELS

Two models were developed to explain temporal changes in residential property value. One model expresses value changes in absolute terms, whereas the other expresses change in percentage terms. Both models have the following format:

$$
\begin{aligned}
\text{CHANGE IN PROPERTY VALUE} \quad = \; & a_1 \times \text{POPULATION DENSITY CHANGE} \\
& + a_2 \times \text{HOUSING DENSITY CHANGE} \\
& + a_3 \times \text{RACIAL COMPOSITION CHANGE} \\
& + a_4 \times \text{ZONING CHANGE} \\
& + a_5 \times \text{INITIAL PROPERTY VALUE} \\
& + b_1 \times \text{DISTANCE}_1 \times \text{CHANGE IN INFLUENCE}_1 \\
& + \cdots + \\
& + b_j \times \text{DISTANCE}_j \times \text{CHANGE IN INFLUENCE}_j \\
& + b_{j+1} \times \text{DISTANCE-TO-WATER FUNCTION} \\
& + \text{CONSTANT} \quad + \text{RANDOM ERROR}
\end{aligned}
$$

The left side of the equation is the change in property value. Value change for the absolute model is calculated as follows:

Change in Value, $\Delta V = V_{70} + CT_{70} - (V_{60} + CT_{60}) \times PI$

where V_{70} = Sales price in 1970.
CT_{70} = Capitalized value of real property taxes in 1970.
V_{60} = Sales price in 1960.
CT_{60} = Capitalized value of real property taxes in 1960.
PI = Rate used to inflate 1960 values to 1970 dollar values.

In the "percentage change" model, change is expressed as:

$$\frac{\Delta V}{PI \times V_{60}}$$

We analyzed both absolute and percentage value change models for two reasons. First, it was uncertain whether an amenity such as a proximate water resource raises ail property values by a fixed amount, as in the absolute value model, or whether the increase in value depends on the original value of the property, as in the percentage change model. The results from both models were consistent, and indicated that the increase in value due to pollution abatement does depend on the initial property value as implied by the percentage change model for single-family residences. That is, the benefit to the owner of a 100,000-dollar home might be a 10,000-dollar increase in its value, whereas the benefit to the owner of a 10,000-dollar home next door might be only 1000 dollars. (Both increases are 10 percent of the initial property value, but the absolute value model would attribute the same benefit to both properties.)

The second reason for analyzing percentage change as well as absolute change is more subtle. If properties near the water tend to be more expensive as is frequently the case, a colinearity will exist between distance to the water and property value. The colinearity can lead to difficulties in separating property value changes due to inflation and increases in the demand for all property from changes due to pollution abatement. This ambiguity is avoided to some degree by using the percentage change model.

One explanation for the better results of the percentage increase model is that the amount people are willing to pay for an amenity such as a water resource depends upon their income and higher income families, who buy higher priced homes, are willing to pay more for improved water quality.

The terms on the right side of the model equation are explained in the following paragraphs.

POPULATION DENSITY CHANGE, HOUSING DENSITY CHANGE, and RACIAL COMPOSITION CHANGE are all important variables, expressing changes in community character which may affect property values. U.S. Census data for 1960 and 1970 were used to measure the changes in these variables by Census tract. Sites were selected for study only where the changes in these variables were so small that they could have no appreciable affect on changes in property values and hence could be eliminated from the regression.

ZONING CHANGE can be treated as a dummy variable with its value either one or zero, depending on whether the property was or was not within an area rezoned between 1960 and 1970. Such zoning changes can have important effects on property values, principally by affecting expectations. Zoning changes can be determined from maps in the offices of local planning authorities. The number of parcels of land rezoned within our sites was so small that we removed them from the sample thus eliminating the zoning variable from further consideration.

INITIAL PROPERTY VALUE is the 1960 market value of the property. This term is particularly important in the absolute value change model because it captures the change in value due to simple capital appreciation, that is, properties of greater value increase in value in the same proportion as do parcels of lesser value. This term becomes important in the percentage change form of the model if a great variation in property values exists at the study site and market demand is substantially different for high- and low-valued properties.

CHANGE IN INFLUENCE is any change in the area, such as construction of a school, shopping center, or highway access, which may have an impact on property values. It can also represent major changes in these types of influences, such as expansion of a school or improvement of local shopping facilities. An implicit assumption in the form of this term is that the magnitude of the impact of any of such influence on the value of any particular property will be proportional to the distance between the property and the influence. Our earlier studies have shown that the influence of these nuisances and amenities on the value of properties near them is best represented by an expression which depends directly upon the distance between each property and the influencing factor. The most appropriate expression in each particular instance will be discussed with each specific equation.

DISTANCE-TO-WATER FUNCTION expresses the form of the relation between property appreciation due to water quality improvement and the distance from the water. Two functional forms were tested, a linear function of distance and a function inversely proportional to distance. Both forms are diagrammed in Figure 2. On the basis of our earlier results, we initially assumed in both cases that the influence of the river or lake was negligible beyond 4000 feet. In some cases it was found that the limit of influence approximated 2000 feet. The inverse form of the distance function provided the best statistical results in most cases.

The CONSTANT TERM accounts for any effects which the other terms of the equation have not specifically accounted for but which exert a predominant influence in increasing or decreasing property values over the period of analysis. Such effects as an increase in air pollution will be accounted for by this term.

The RANDOM ERROR term accounts for all of the random effects which may have exerted an influence on the change in value but which did not produce a predominant inflation or deflation of property values.

In selecting independent variables for inclusion in the property change model it is integral to include all those factors which might be colinear or confused with a water pollution abatement impact. For example, if a new park were created along the water's edge during the same period that water quality improved, the regression analysis would be unable to distinguish the benefits due to the park from the benefits due to improved water; they act colinearly. We selected sites carefully to avoid including simultaneous improvements, while any influence which was suspected of colinearity with the water quality improvement was included in the model so that the magnitude of its effect could be identified.

Some variables which are significant determinants of property value changes can conveniently be ignored if their absence does not affect measurement of the water impact. The value of improvements which have been added to each property during the period of analysis is one such variable. For established, well-maintained residential areas such as our study sites, home improvements will tend to be relatively small and random. Thus the errors introduced by ignoring this variable can be expected to be small and random and in no way confusable in the final analyses with effects due to pollution abatement. The object of our model is to isolate property value changes attributable to water quality changes, rather than to explain completely why a property value changes.

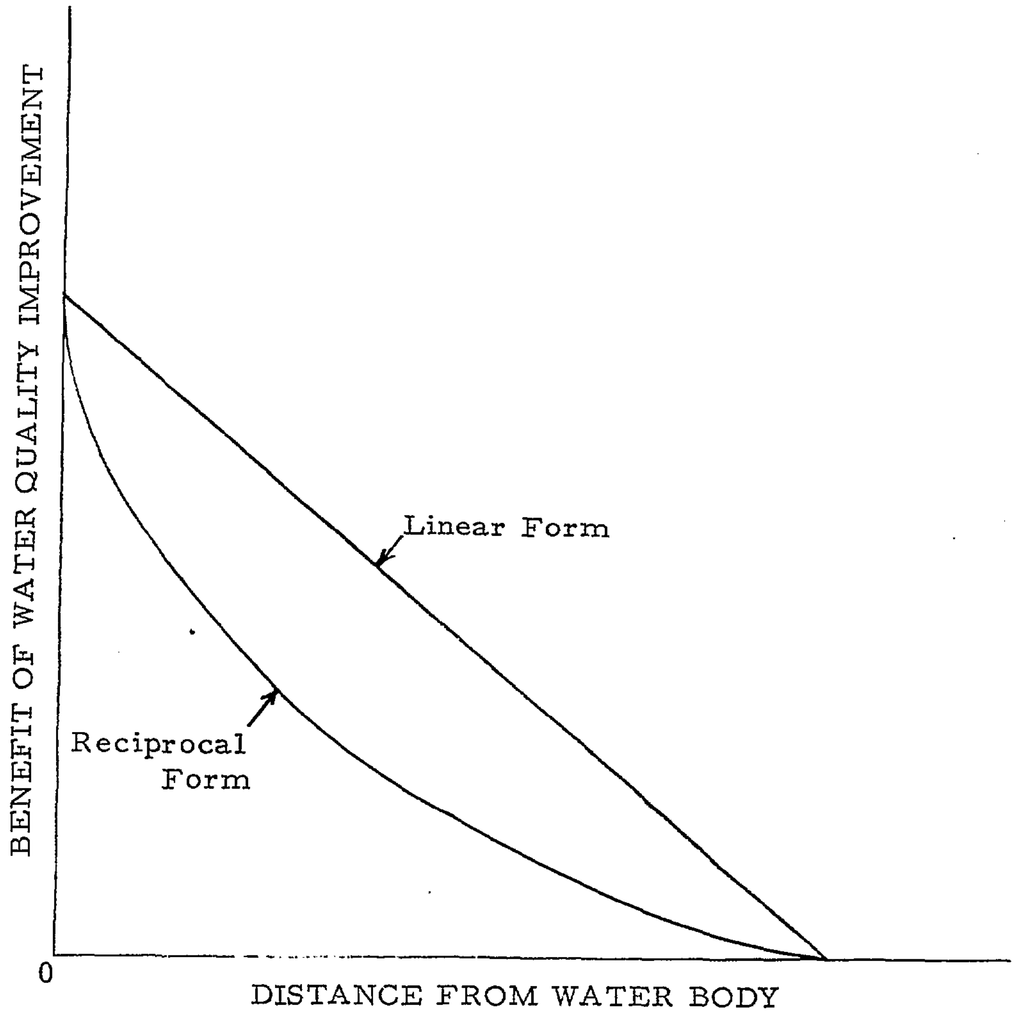

Figure 2

THE LINEAR AND RECIPROCAL FORM OF WATER QUALITY INFLUENCE

Section IV

Site Descriptions and Case Study Results

Property value changes were analyzed for six urban residential sites and one rural site. This section describes the water quality change, property characteristics, and regression results for each study site. Each subject, such as water quality or property characteristics, will be discussed for all the sites together rather than treating the three subjects on a site-by-site basis. This organization will serve to highlight the differences between sites and avoid repetition. Water quality data, specifics about data used in the value change calculation, and a map of influences, are included in Appendices A through F. The regression results are summarized in Tables 6, 7, and 8. Raw data and correlation coefficients for all sites are included in Appendix K.

WATER QUALITY CHANGES

Five major water resources were located where significant, well-documented water quality changes had taken place between 1960 and 1970. Each of these water bodies has been the focus of deliberate municipal and industrial clean-up action after it reached or was approaching a highly polluted condition.

1) San Diego Bay - Located on the Pacific Coast in Southern California, the Bay is an important recreational resource as well as a military and commercial fishing port.

2) Willamette River - This river runs generally northward through western Oregon to its confluence with the Columbia River at Portland. Two-thirds of all Oregonians live in the Willamette River Valley, where the principal economic activities are agriculture, lumber, wood pulp and related industries.

3) Ohio River (Pennsylvania) - The Ohio River, America's major industrial river, is formed by the confluence of the Allegheny and Monongahela Rivers at Pittsburgh, running through six states and joining the Mississippi at Cairo, Illinois.

4) Kanawha River - The Kanawha is a tributary of the Ohio, lying wholly within West Virginia.

5) Lake Washington - This large lake is located within the Seattle metropolitan area. The history of water quality changes on Lake Washington is discussed in Appendix G.

In 1955, pollution in San Diego Bay was characterized by frequent algae blooms, low dissolved oxygen concentrations, and high concentrations of bacteria associated with sewage treatment plant discharges (fecal coliforms). The bay was unfit for swimming, unhealthy for wildlife, and unsightly. Sludge deposits were accumulating on the bottom of the Bay and floating oil and debris were frequently visible on the water's surface. The primary cause of the pollution was the discharge into the Bay of large quantities of insufficiently treated municipal and industrial wastes from San Diego and surrounding communities. These Biochemical Oxygen Demand (BOD) loads depleted the Bay's dissolved oxygen, thereby inhibiting fish populations, and enriched the water with nitrates and phosphates, enabling large undesirable algae populations to flourish.

The principal corrective actions, taken in the early 1960's, were the consolidation of waste treatment plants, improvement of treatment, and the diversion of waste discharges to a Pacific Ocean outfall. Recovery of water quality was rapid after the waste diversion. Although San Diego is still in the process of decreasing its waste discharges to the Bay, the major water pollution control benefits have already been realized. Today, the dissolved oxygen concentrations throughout the Bay remain above five parts per million, fecal coliform levels are low, sludge deposits are disappearing, and the water is now fit for people's swimming and indigenous fish species.

Another dramatic improvement in water quality has been realized on the lower Willamette River. In the 1940's this portion of the river was popularly referred to as "an open sewer." Inadequately treated, oxygen-demanding municipal wastes and industrial wastes produced principally by wood pulp processing plants, had badly polluted the river. The worst conditions occurred during the summer and early fall seasons, when water flows were at very low levels, and dissolved oxygen levels approached or reached zero, while fecal coliform counts greatly exceeded health standards. Sludge had accumulated on the river bottom and debris from logging operations and sewage treatment plant overflow cluttered the surface.

About thirty years ago, water quality restoration efforts were begun in the Willamette Valley, with the result that by 1970 the Willamette River met all applicable water quality standards throughout the year over its entire length. This dramatic water quality improvement was the product of several new procedures. First was municipal and industrial waste treatment improvement and regulation of discharges. Second, the storage of water behind flood control dams has permitted low flow augmentation. That is, water stored during the heavy spring run-off is released in the summer and fall to supplement the lighter run-off to maintain a sufficient flow to dilute waste loads. To complement low flow augmentation, withdrawals of water by industry and agriculture are limited during critical periods. The major portion of this water quality improvement took place between 1960 and 1970, the period of our study.

The large Ohio River has a highly industrialized basin. Water quality has improved at several points within the Ohio River Valley since the early 1950's, when a compact formed between eight principal states created the Ohio River Valley Sanitation Commission (ORSANCO) to set standards and reduce pollution. Excellent water quality data from ORSANCO indicates that in the river reach just downstream of the Pittsburgh metropolitan area and its giant steel-making complex, the minimum monthly average dissolved oxygen has increased twenty percent during the period 1963 to 1970, to over six milligrams per liter. Average specific conductivity (a rough measure of industrial chemical pollution) has decreased twenty percent, while minimum average pH is up approximately ten percent. The rising pH is in part the result of efforts to limit acid mine drainage into the tributary streams of the Ohio. A major new consolidated municipal waste treatment plant which began operations at Pittsburgh in 1960 has also had its effect. In 1967 a major dam project was completed on the Alleghany River. Releases of water from behind this dam have augmented Ohio River flows during the critical summer months, reducing pollution concentrations by dilution. However, the measured improvements on this reach of the Ohio are modest compared to those in San Diego Bay or the Willamette River. and we were not certain at the outset of this study that we could measure an impact on residential property values. Our doubts have proven to be justified, as inconclusive results indicate that the impact was apparently small.

The Kanawha River is relatively small, with an average flow of about 9000 cubic feet per second compared to 94,000 for the Ohio at Cincinnati. However, it is burdened with the waste discharges of one of the largest petro-chemical industrial complexes in the United States. In 1960, the Kanawha was grossly polluted. The lower reaches of the river were in a septic condition (zero dissolved oxygen) during a third of each year.

A phased municipal and industrial clean-up program was implemented in the Kanawha Valley in 1958. Removal of visual pollutants, a 40 percent reduction in the BOD (Biological Oxygen Demand) wastes from industrial sources, and primary treatment of sewage by all towns was accomplished by 1964. A program initiated in 1964 requiring a 50 percent reduction of remaining wastes as well as secondary sewage treatment was well underway by 1968. On the lower portions of the Kanawha the changes in water quality have been large. Changes in the vicinity of Charleston where our study sites were located are measurable but not dramatic. The most significant change at Charleston has probably been the undocumented decrease in visual pollutants.

PERCEPTION OF WATER QUALITY CHANGES

Significant changes can occur in the condition of a water body without their being readily apparent to people. If water quality improvements are to change peoples' valuation of a water resource and their valuation of surrounding property in turn, the people must be aware that the changes have taken place. In order to determine to what extent people actually were aware of the water quality changes described above, we interviewed people at five of the study sites located on three of the water bodies.

The five interview sites were selected where preliminary analysis indicated positive impacts of pollution abatement on property values. Our sample included 160 people (80 men and 80 women) who own and live in homes located within 4000 feet of three of the water bodies. None of the persons interviewed owned property in common with other members of the sample. Forty persons were interviewed at the urban site and forty at the rural site on the Willamette River; forty were interviewed at the San Diego Bay site (the City of Coronado) as well as a total of forty at two sites on the Kanawha River near Charleston, West Virginia.

The questions asked each of the residents are listed below in the order they were presented.

1) Do you think there has been any change in the quality of the water of the (name of river, bay) since 1960?

If the respondent answered “yes” to question 1 then questions 2 and 3 were asked.

2) Would you say the water quality is better or worse than it was then?

3) Would you say much, somewhat, or only slightly (better or worse)?

4) Would you say the water of the (name of river, bay) nearest to where you live looks different now than it did say, 10 or 15 years ago?

If the respondent answered “yes” on question 4, then questions 5 and 6 were asked.

5) How would you describe the difference?

6) Do you agree or disagree with the following statements? (Agree completely, agree somewhat, neither agree nor disagree, disagree somewhat, disagree completely).

a) The water is clearer now than it was.

b) There is less floating debris and refuse than there was.

c) The water smells better.

d) There seems to be more wildlife now.

e) There are fewer dead fish now than there were.

f) The color of the water is better now.

7) Compared to 1960, do you think there is more, less or about the same amount of boating on the (name of river, bay)?

8) Would you say there is more, less or about the same amount of swimming in the (name of river, bay) as there was in 1960?

9) Would you say there are more, less or about the same number of fish in the (name of river, bay) than there were in 1960?

10) Do you think there are more, less or about the same number of water birds now as there were 10 or 15 years ago?

The general consensus of the Willamette River and San Diego Bay respondents was that the water had definitely improved since 1960; they thought the water was clearer and smelled better, the color was improved and there was less floating debris and oil, and fewer dead fish than there was before. The respondents seemed to be divided only on whether or not there was more wildlife now than in 1960.

A greater difference of opinion was found at the Kanawha River sites. There, 39 percent of the respondents said they thought the water was worse than in 1960, while 27 percent thought it was better, and 34 percent thought there was no change or had no opinion. Nonetheless, the responses to question 6 seem to indicate that there is some awareness of an improvement in the decrease of floating debris and numbers of dead fish (questions 6b and 6e). This response correlates with the clean-up of visual pollution which was accomplished on the Kanawha by 1964. The results of the interviews are summarized graphically in Tables 1, 2 and 3.

The interview results definitely support the results of the regression results reported later. Where people perceived large water quality improvements, substantial impacts on property values were measured (on the Willamette River and San Diego Bay sites). On the Kanawha River, where people perceived little or no water improvement the regression analysis showed small impacts on property values.

SITE CHARACTERISTICS

The residential and rural sites where water quality impacts were measured in this study are described below.

San Diego Bay (Coronado) - Coronado is a residential community about one and one-half miles square, located on a peninsula directly across the Bay from downtown San Diego (see map of Figure 3). Coronado is connected to San Diego by a toll bridge which was completed in 1969. Coronado is bounded on the north and east by San Diego Bay, on the west by a Navy base, and on the south by the Ocean; there are no significant barriers between residences and the waterfront. On the north side private property extends up to the water, and there is a municipal golf course and marina on the east side with public access.

Q. 1 Do you think there has been any change in the quality of the water of the (name of river or bay) since 1960?

Q. 2 [If respondent answered "yes" on q. 1 then q. 2 and q. 3 were asked.] Would you say the water quality was better or worse than it was then?

Q. 3 Would you say the water quality was much, somewhat, or only slightly (better or worse)?

Q. 4 Would you say the water of the (name of river, bay) nearest to where you live looks different now than it did, say, ten or fifteen years ago?

	SAMPLE SIZE	Q. 1 YES	Q. 1 DON'T KNOW	Q. 1 NO	Q. 2 BETTER	Q. 2 WORSE	Q. 3 MUCH	Q. 3 SOMEWHAT	Q. 3 SLIGHTLY	Q. 3 SLIGHTLY	Q. 3 SOMEWHAT	Q. 3 MUCH	Q. 4 YES	Q. 4 DON'T KNOW	Q. 4 NO
WILLAMETTE RIVER - URBAN -	42	83	7	10	89	11	51	26	11	0	6	6	76	5	19
WILLAMETTE RIVER - RURAL -	42	74	12	14	71	29	32	26	13	3	13	13	48	28	24
SAN DIEGO BAY	41	68	15	17	75	25	43	14	18	7	11	7	41	18	41
KANAWHA RIVER	41	66	27	7	41	59	15	19	7	0	44	15	59	17	24

TABLE 1 - RESIDENTS' INTERVIEW RESPONSES

WATER QUALITY CHANGE

Q. 6 -Do you agree or disagree with the following statements?

Percentages per statement, in order: Completely Agree / Somewhat Agree / Neither Agree nor Disagree / Somewhat Disagree / Completely Disagree (scale 0–100)

	SAMPLE SIZE	The water is clearer now than it was -	There is less floating debris and refuse than there was -	The water smells better -	There seems to be more wild life now -	There are fewer dead fish now than there were -	The color of the water is better now -
WILLAMETTE RIVER - URBAN -	42	50 22 3 19 6	37 34 3 13 13	41 28 16 3 12	0 31 31 22 16	25 31 28 3 13	37 31 6 13 13
WILLAMETTE RIVER - RURAL -	42	45 20 0 15 20	35 0 15 30 10	25 15 25 25 10	5 10 40 25 20	20 30 30 15 5	30 20 5 20 25
SAN DIEGO BAY	41	44 25 25 0 6	63 25 6 6 0	40 33 20 7 0	20 13 27 7 33	33 14 33 14 6	44 25 6 25 0
KANAWHA RIVER	41	8 8 4 21 59	12 25 4 34 25	8 8 17 42 25	0 17 25 29 29	12 17 29 21 21	4 4 8 25 59

TABLE 2 - RESIDENTS' INTERVIEW RESPONSES

WATER QUALITY CHANGE

	SAMPLE SIZE	Q. 7 Compared to 1960, do you think there is more, less, or about the same amount of boating on the (name of river, bay)?			Q. 8 Would you say there is more, less, or about the same amount of swimming in the (name of river, bay) as there was in 1960?			Q. 9 Would you say there are more, less, or about the same amount of fish in the (name of river, bay) than there were in 1960?			Q. 10 Do you think there are more, less, or about the same number of water birds now as there were 10 or 15 years ago?		
PERCENTAGE		MORE	SAME	LESS	MORE	SAME	LESS	MORE	SAME	LESS	MORE	SAME	LESS
WILLAMETTE RIVER - URBAN -		85	5	10	51	5	44	44	12	44	10	37	53
WILLAMETTE RIVER - RURAL -		97	0	3	37	6	57	38	14	48	7	32	61
SAN DIEGO BAY		95	5	0	78	9	13	41	0	59	12	21	67
KANAWHA RIVER		84	11	5	15	18	67	13	23	64	4	69	27

TABLE 3 - RESIDENTS' INTERVIEW RESPONSES

WATER QUALITY CHANGE

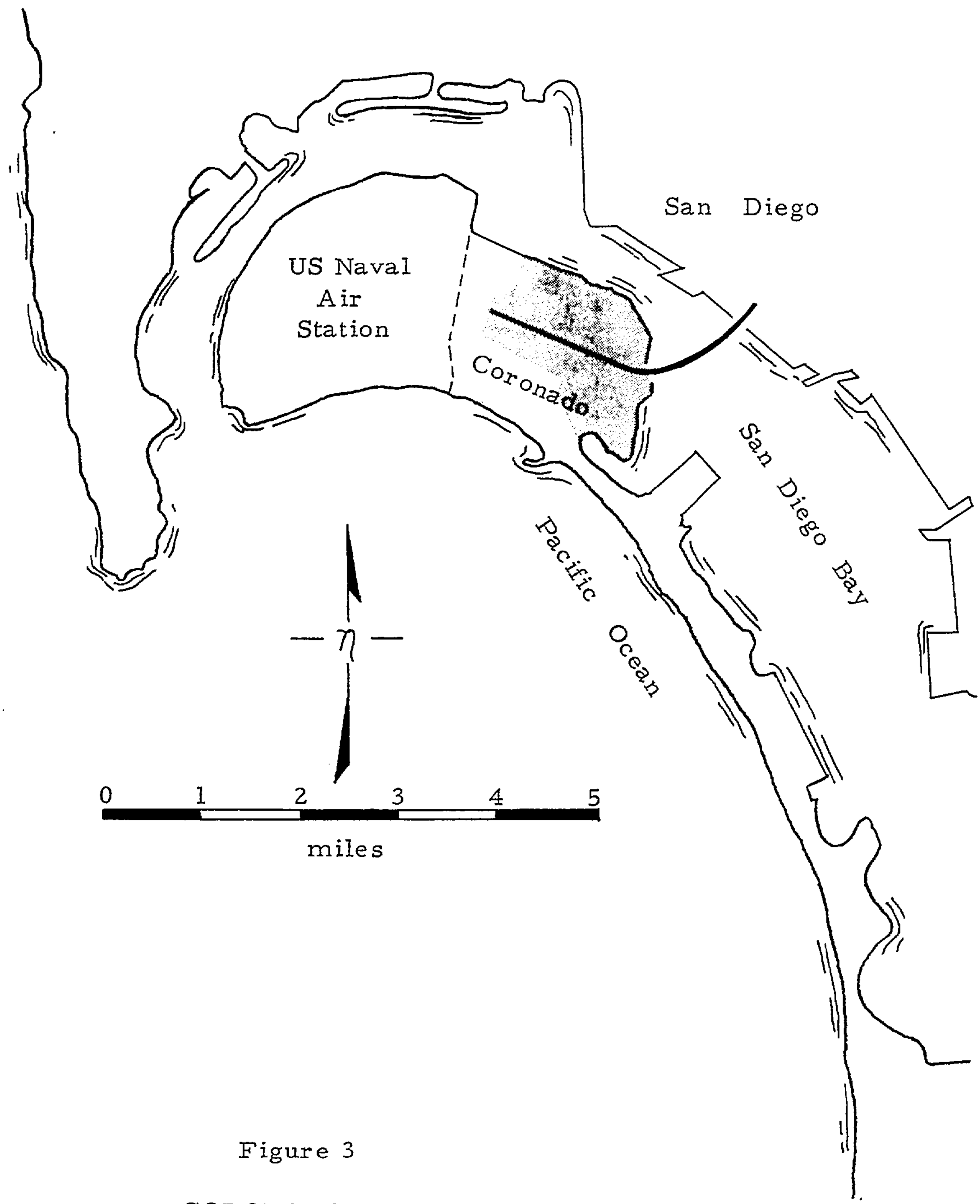

Figure 3

CORONADO SITE
(SAN DIEGO BAY)

Sales prices and assessed values were collected for all of that portion of Coronado which lies within 4000 feet of the Bay (about three-fourths of the city).

Willamette River (Clackamas County, Oregon – Residential) – Residential property extends along both banks of the Willamette River between Portland and Oregon City. One area was particularly well-suited for investigation because of its size (about two miles long and one mile deep) and lack of obstructions. The area is in an unincorporated portion of Clackamas County known as Oak Grove and Jennings Lodge. The map of Figure 4 shows the relationship between the site, the river, and other towns. Single-family houses over 15 years old dominate the site. Private property extends to the river banks, although there are several access points for fishing or boat launching. The bank opposite the site is uncluttered and scenic.

Willamette River (Clackamas County, Oregon – Rural land) – Between Oregon City and Salem, Oregon the Willamette is bordered by predominately rural tracts on both banks. Data was collected for small rural land parcels which sold in the years between 1968 and 1972, and which had not changed in size or shape since 1960. The study site was defined as both banks of the river upstream of Oregon City for about eighteen miles. This area includes portions of Clackamas. Yamhill, and Marion Counties, but because of availability of data most tracts included in the sample are in Clackamas County. See Figure 4 for a map of the rural area. The original sample included unimproved land parcels as well as land parcels with buildings. Our preliminary analysis revealed no correlation between land value and value of improvements (buildings), so only land values were studied further.

The demand for land in this area is substantial because of its proximity to rapidly growing metropolitan Portland. The rural area is atypical in this sense and study results should be interpreted as representative of rural land near a growing population concentration rather than general agricultural land.

Water clean-up has renewed interest in the Willamette River to the extent that the State of Oregon is presently acquiring as much of the river banks as possible (possibly 200 miles) for parks and greenways.

Kanawha River (Charleston, West Virginia) – This site consists of a dense residential area 10,000 feet by 3,000 feet in the Kanawha City section of Charleston. It is on the south bank of the Kanawha River almost directly across from the West Virginia state capital (see Figure 5). The settlement is primarily single-family residential with some multi-family properties and one major commercial avenue. There is no public recreational property within the site. The river bank itself is privately owned, with very limited public access.

The major development at this site took place before 1955.

Kanawha River (Dunbar, West Virginia) – Dunbar is a town of 9000 people immediately downstream of Charleston, West Virginia on the north bank of the Kanawha River (see Figure 5). The residential area studied (5000 by 2000 feet) lies

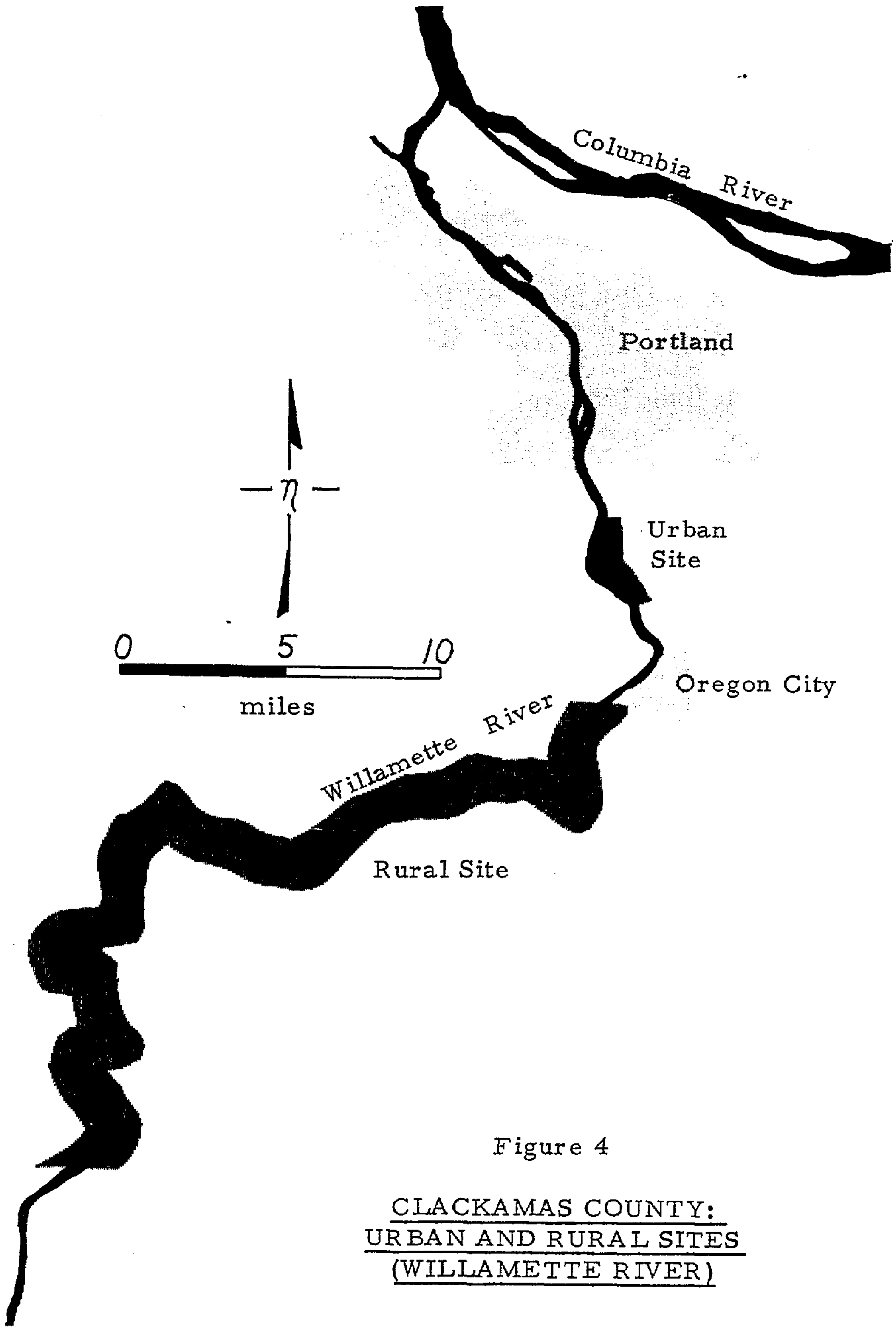

Figure 4

CLACKAMAS COUNTY:
URBAN AND RURAL SITES
(WILLAMETTE RIVER)

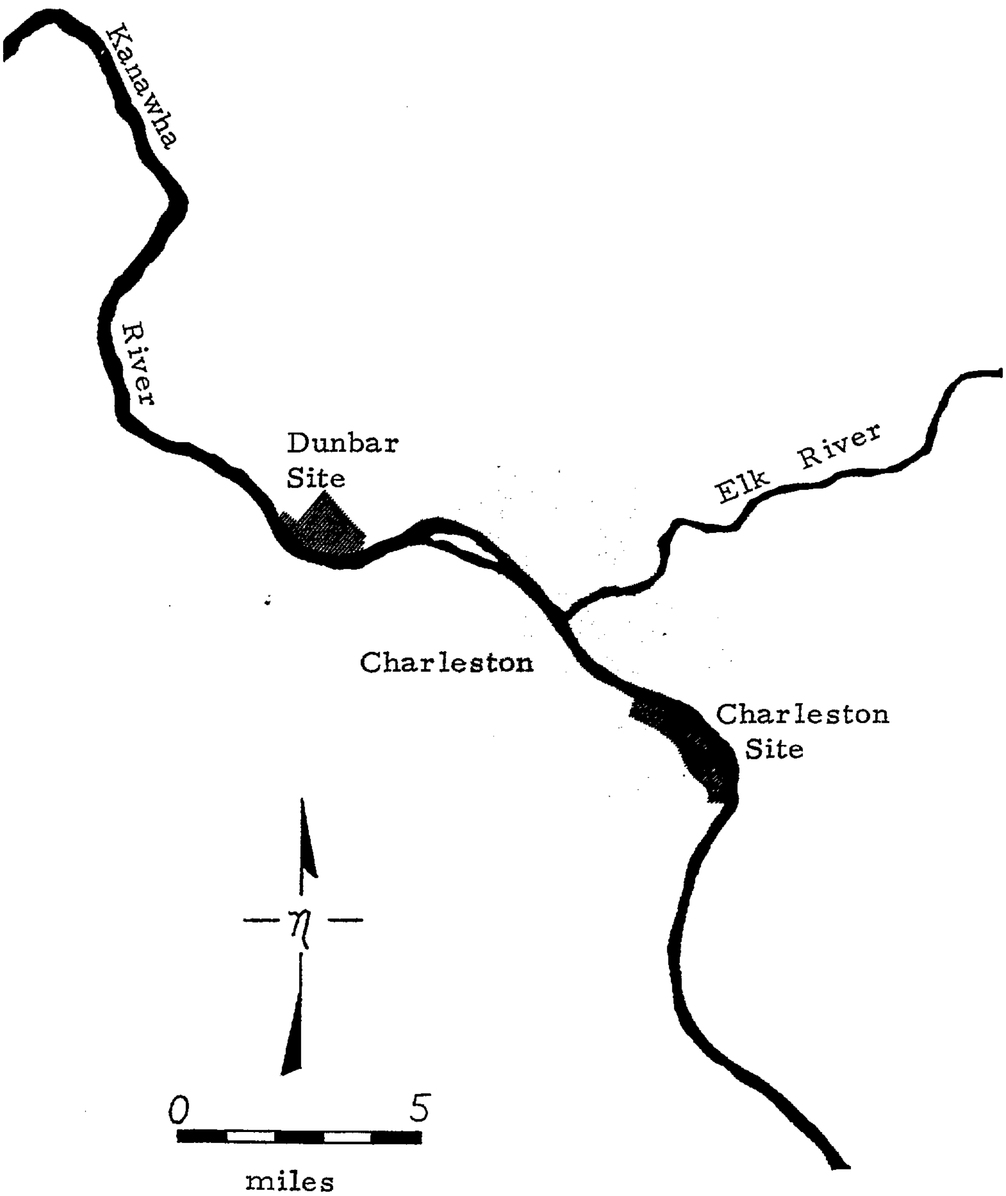

Figure 5

CHARLESTON AND DUNBAR SITES
(KANAWHA RIVER)

in an unobstructed area between the river and a railroad line. There is no public recreational property within the site, and the river bank is occupied by private residences. The primary difference between the Charleston and Dunbar sites is the average value of single-family homes. The average value in Dunbar is about $17,000, whereas the average value of houses in the Charleston site is $27,700.

Ohio River (Beaver, Pennsylvania) – This site includes the entire borough of Beaver, Pennsylvania (population 6000). Beaver is located on a high bank (60 feet above water) overlooking the Ohio River twenty miles downstream from Pittsburgh (see Figure 6). The development is primarily older single-family dwellings. with some concentrated commercial property.

There is a narrow linear park on the crest of the bank overlooking a scenic stretch of the Ohio for most of the length of Beaver. Immediate actual access to the water is limited by the high bank.

We collected, processed, and analyzed data for all of the above sites. We first analyzed data samples to identify important property value influences and significant correlations between important variables. Two quantitative variables are said to be correlated if there is an association between them. If the value of one does not depend on the value of the other, then the correlation coefficient of the two is zero and they are called independent. If the value of one variable does depend on the other the magnitude of the correlation coefficient will approach one as the dependence increases. For example, the value of homes and homeowners' incomes should be highly correlated; whereas, the value of the home and the last digit of the owner's telephone number would have a low correlation coefficient because there is no apparent association between the variables.

Table 4 lists the important correlation coefficients and property statistics for each of our study sites. All values are for single-family residences except the entries for the rural area (row 3), which are expressed in terms of value per acre of land. Average 1970 property values for the samples of single-family residences varied from $16,412 at the Dunbar. West Virginia site to $49,062 dollars at the Coronado, California site. Lot size or property area ranged from 6,088 square feet at Coronado to 22,630 square feet at the urban site in Oregon. Lots at all the other residential sites were closer to the size of those in Coronado.

It is important to observe that at the residential sites, all the correlation coefficients between 1960 property value and distance from the property to the water are negative and small in magnitude (Table 4). In other words, there is a slight tendency for higher-priced properties to be closer to the water, and this tendency supports the hypothesis that property values within the residential sites are positively influenced by the water resources. If the water bodies were a nuisance, or represented a flood hazard, as on some river banks, this relationship could not be expected to hold.

It is further notable (referring still to Table 4) that the correlation between 1960 property value (V_{60}) and the "percent" change in property value between 1960 and 1970 ($\frac{\Delta V}{V_{60}}$), is also generally negative. This implies that the values of higher-priced

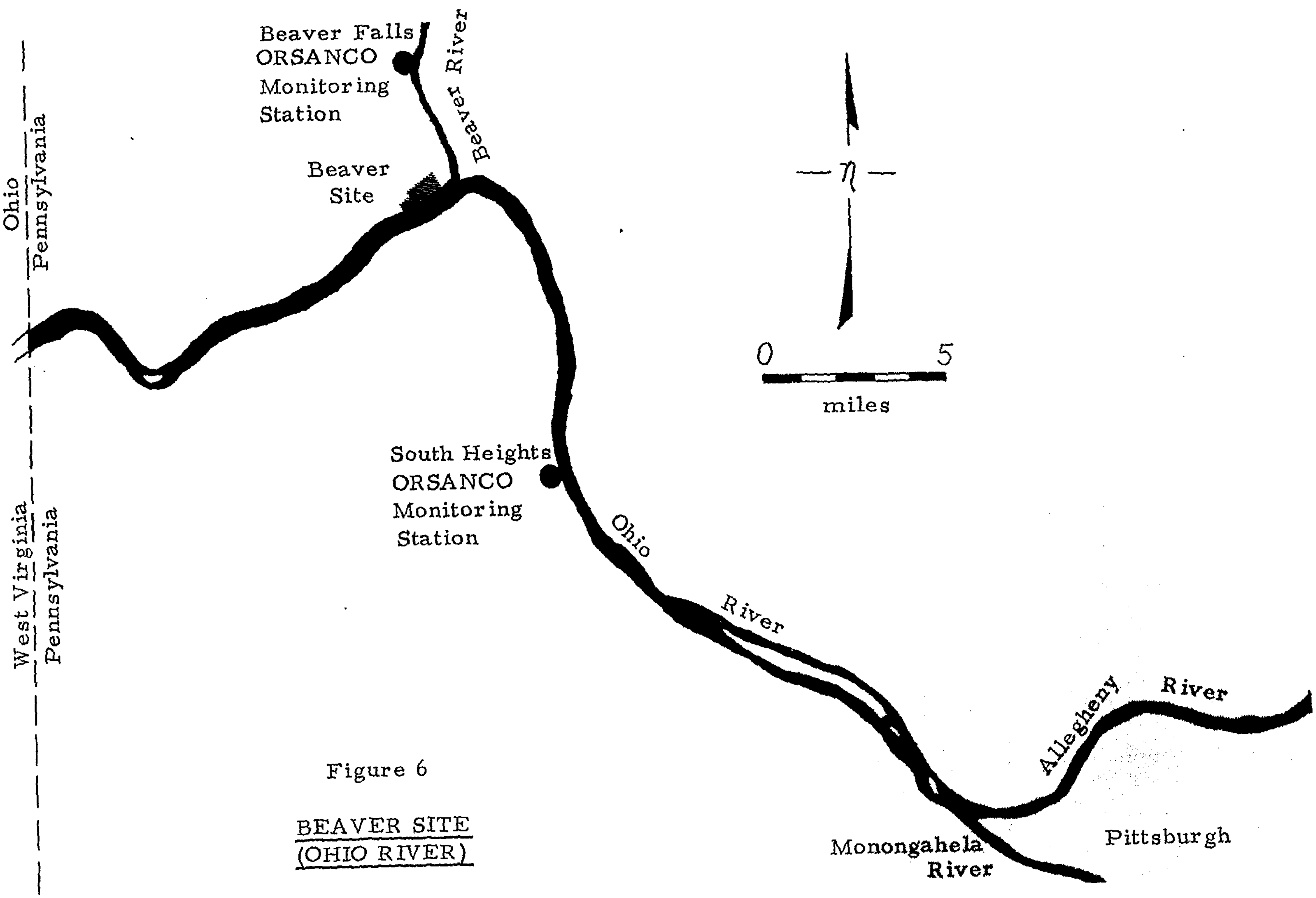

Figure 6

BEAVER SITE
(OHIO RIVER)

Table 4. IMPORTANT CORRELATION COEFFICIENTS AND PROPERTY VALUE STATISTICS

Location	Sample Average					Correlation Coefficients			
	V_{70} $ per res.	ΔV $ per res.	$\frac{\Delta V}{V_{60}}$	$\frac{V}{A}$	A	V_{60}-dw	V_{60}-ΔV	V_{60}-$\frac{\Delta V}{V_{60}}$	V_{60}-A
Coronado, Calif. (San Diego Bay)	49,062	13,855	.435	8.29$/ft^2	6,088ft^2	-.03	.75	.11	.47
Clackamas County Oregon Residential (Willamette River)	25,844	3,725	.168	1.28$/ft^2	22,630ft^2	-.37	.13	-.30	.25
Clackamas County Oregon Rural Land (Willamette River)	8,688$/acre	4103$/acre	1.90	8688$/acre	7.16 acre	.19	.33	-.25	.51
Charleston, W. Va. (Kanawha River)	26,241	-1809	-.05	3.95$/ft^2	7,878ft^2	-.18	-.32	-.23	.61
Dunbar, W. Va. (Kanawha River)	16,412	-2	.11	3.20$/ft^2	6,185ft^2	-.28	-.64	-.55	.44
Beaver, Penn. (Ohio River)	22,511	2,322	.14	4.03$/ft^2	6,460ft^2	-.36	-.27	-.34	.54

V_{60} = Value in 1960 (no taxes); ΔV = Change in value; A = Area; res = residence; dw = Water distance properties within the sample were inflated slightly less by demand pressures over the ten-year period than the values of lower-priced properties.

Negative values in Table 4 for the average change in value at Charleston and Dunbar mean that the change in housing values at these sites did not keep up with the changes in the national Consumer Price Index, used to inflate 1960 housing prices to 1970 dollar values. The change in the Consumer Price Index was 31 percent [8].

We originally thought that it might be desirable to use change in value per unit area as a measure of water resource impact because of its simple interpretation. However, we eventually rejected this measure for the residential sites because of the lack of a strong correlation between property value and lot size; that is, many expensive houses are built on small lots and vice versa.

We collected all available sales data which met the study requirements at each site. For example, at the Willamette River residential site all houses located within 4000 feet of the river which had been sold in 1969, 1970, or 1971 were plotted and their actual sales prices recorded. We then examined tax records for 1960 to determine the 1960 assessed values of the property, and to eliminate from the samples any properties which changed in size or number of buildings between 1960 and the year of sale. Given the site boundaries and available sales data, we maintained the largest sample sizes possible.

We also collected data for vacant lots, but since samples of sufficient size for meaningful multiple-regression analysis were obtainable for single-family residential properties alone, vacant lots had to eventually be excluded from analysis. This is not a serious deficiency since single-family residences account for an average 83 percent of the total value of taxable residential property, nationally, while total taxable value of vacant lots constitutes less than 3 percent of the total value of residential properties [7] (see Table 5 for a breakdown of gross national property value by type of property). Therefore, by measuring the pollution abatement impact on the value of single-family homes, we are analyzing that property type to which most of the benefits will accrue within metropolitan areas. Finally, although it was not used for regression analysis, the vacant land value data we obtained is valuable for imputing a value to park and recreation land in the national benefit part of this study.

REGRESSION RESULTS

As discussed in Section III, two models of property value increase attributable to pollution abatement were analyzed using multiple-regression analysis. One model expressed value change in percentages and the other in absolute value change. The use of two models allows us to check back and forth between them for consistency.

Property value changes attributable to water quality improvement were found to be substantial and statistically significant for the residential and rural sites on the Willamette River and for the San Diego Bay site (Coronado). Results for the Charleston site on the Kanawha River were significant but indicated a smaller water quality impact. Results for the Dunbar site on the Kanawha River and for the Beaver, Pennsylvania site on the Ohio

Table 5. GROSS TAXABLE VALUE OF LOCALLY ASSESSED REAL PROPERTY

Type of real property	Gross assessed value		Properties	
	Amount (billions dollars)	Percent	Number (thousands)	Percent
Total..........	393.2	100.0	74,832	100.0
Residential (non-farm)..	236.3	60.1	42,329	56.6
Single-family houses..	196.7	50.0	40,436	54.0
Acerage and farms	43.4	11.0	14,085	18.8
Vacant lots	10.2	2.6	14,250	19.0
Commercial and industrial properties.....	97.2	24.7	2,487	3.3
Commercial	60.0	15.3	2,112	2.8
Industrial...........	37.1	9.4	376	0.5
Other and unallocable...	6.0	1.5	1,679	2.2

Source: <u>1967 Census of Governments</u> [7]

River were statistically inconclusive.

Actual final regression equations are listed in Tables 6 and 7. Table 6 reports the results of the percentage change model while Table 7 reports the results of the absolute value change model.

The first term on the right-hand side of each equation in Tables 6 and 7 is that portion of the change which the multiple regression computation attributes to the change in water quality. The leading coefficient of this term is determined by the regression computation. This coefficient depends upon the data sample being regressed, the correlation between independent variables, and also upon the form of the remainder of this term (the distance-to-water function). The distance-to-water function (in parenthesis) expresses how the property value benefit of pollution abatement changes with distance from the water.

The form of this function is hypothesized and then verified experimentally. See Figure 2 for a graphical comparison of a linear and a reciprocal distance function. Reciprocal functions of distance usually yielded better results than linear distance terms, except for the Coronado site. The constants appearing in the water distance function are determined by the rate at which benefits decrease as distance from the water increases and also by the maximum distance at which a benefit is realized (2000 or 4000 feet).

Standard errors of the coefficients, degrees of freedom (dof), and multiple correlation coefficients (R^2) are also included in the tables. The standard error together with the degrees of freedom indicate with what degree of confidence we can assert that the regression coefficient is not equal to zero. The results for which the probability is greater than .95 that the distance-to-water coefficient is not equal to zero, based on our sample, are marked with a dagger.

R^2 is a measure of the fraction of the total variation in property value changes which is explained by the regression equation or model. The R^2 factor varies from values of .10 for the Charleston site to .72 at Coronado. This range of R^2 values is acceptable for our study since we were not attempting to explain all of the variation in property values, but were only concerned with isolating the property value change attributable to water quality changes. Therefore, while any influence that might interfere with the isolation of the water impact must be taken into account, factors which do not influence values colinearly with distance to the water can reasonably be neglected. Thus, although high R^2 values are generally desirable, they are not necessary in this application.

Data inputs to the regression equations, and correlation coefficients are listed site by site in Appendix K.

The computed values of the water quality benefit are listed in Table 8 for residences located 100, 500, 1000, and 2000 feet from the water's edge. These values can be interpreted as the best estimate of the capitalized benefit per residence or acre of rural land of the pollution abatement which occurred.

Table 6. REGRESSION EQUATIONS FOR PERCENT CHANGES IN PROPERTY VALUES

Location	
Coronado, Calif. (San Diego Bay)	$(\Delta V / V_{64})(100) = \underset{(0.180 \times 10^{-2})}{0.208 \times 10^{-2}}(4000 - d, \text{water}) + \underset{(0.266 \times 10^{-2})}{0.165 \times 10^{-2}} \left[d, \text{bridge access}\right] - \underset{(0.310 \times 10^{-2})}{0.219 \times 10^{-2}} \left[d, \text{Orange Avenue - Commercial St.}\right] + \underset{(0.150 \times 10^{-2})}{0.623 \times 10^{-2}} \left[d, \text{Navy Base access}\right] + \underset{(0.105 \times 10^{-2})}{0.121 \times 10^{-2}} \left[\text{Lot Area - sq. ft}\right] - \underset{(1.431 \times 10^{-4})}{0.901 \times 10^{-4}} (\text{Property Value}_{1964}) + 15.68$ $R^2 = 0.23$ dof. = 106 where d = distance in feet
Clackamas County, Oregon Residential (Willamette River) †	$(\Delta V / V_{63})(100) = \underset{(0.196 \times 10^{5})}{0.354 \times 10^{5}} \left(\frac{1}{d, \text{water} + 1000} - 0.0002\right) + \underset{(0.00282)}{0.00226} (d, \text{parks}) - \underset{(0.0040)}{0.0121} (d, \text{nearest school}) - \underset{(0.00376)}{0.00155} (d, \text{shopping center}) + \underset{(0.00218)}{[illegible]} (d, \text{Portland}) + \underset{(0.000155)}{0.000637} (\text{lot area - sq. ft.}) - \underset{(0.00051)}{0.00238} (\text{Property Value}_{1965}) + 25.91$ $R^2 = 0.30$ dof. = 90 where d = distance in feet
Clackamas County, Oregon Rural Land (Willamette River)	$(\Delta V / V_{60})(100) = \underset{(0.459 \times 10^{5})}{[illegible] \times 10^{5}} \left(\frac{1}{d, \text{water} + 500} - .00022\right) - \underset{(35.6)}{33.0} (d, \text{nearest boat ramp miles}) + \underset{(8.35)}{5.98} (d, \text{nearest bridge access miles}) + \underset{(9.2)}{10.4} (d, \text{nearest town miles}) + 74.29$ $R^2 = 0.12$ dof. = 29 where d = distance in feet
Charleston, W. Va. (Kanawha River) †	$(\Delta V / V_{60})(100) = \underset{([illegible])}{[illegible]} \left(\frac{1}{d, \text{water}} - .0005\right) - \underset{(0.000659)}{0.000347} (d, \text{bridge access}) - \underset{(0.000216)}{0.000503} (\text{Property Value}_{1960}) + 12.17$ $R^2 = 0.10$ dof. = 61 where d = distance in feet
Dunbar, W. Va. (Kanawha River)	$(\Delta V / V_{60})(100) = -\underset{(1001)}{[illegible]} \left(\frac{1}{d, \text{water}} - .0005\right) + \underset{([illegible])}{0.00777} (d, \text{nearest school}) - \underset{(0.00408)}{0.00138} (d, \text{new highway access}) + \underset{(0.00492)}{0.00984} \left[\text{lot area - sq. ft.}\right] - \underset{(0.00168)}{0.00594} (\text{Property Value}_{1960}) + 58.00$ $R^2 = 0.43$ dof. = 23 where d = distance in feet
Beaver, Penn. (Ohio River)	$(\Delta V / V_{60})(100) = \underset{(5980)}{2930} \left(\frac{1}{d, \text{water}} - .0005\right) - \underset{(0.0171)}{0.0296} \left[d, \text{State Street Commercial St.}\right] - \underset{(0.00701)}{0.00512} (d, \text{Agnew Sq.}) + \underset{(0.00887)}{0.00291} (d, \text{Railroad Station}) + \underset{(0.01385)}{0.00465} (d, \text{High School}) + \underset{(0.000462)}{0.000784} (\text{Property Value}_{1970}) - 0.97$ $R^2 = 0.30$ dof. = 46 where d = distance in feet

† The coefficient of the distance to water term is significant at the 95 percent level of confidence.

The terms in parenthesis below the coefficients are the standard errors of the coefficients.

ΔV includes capitalized value of change in taxes.

Table 7. REGRESSION EQUATIONS FOR ABSOLUTE CHANGES IN PROPERTY VALUES

Location	
Coronado, Calif. (San Diego Bay) †	$\Delta V = \underset{(0.53)}{1.07}\,(4000 - d,\ \text{water}) + \underset{(0.879)}{0.761}\begin{bmatrix} d,\ \text{bridge} \\ \text{access} \end{bmatrix} - \underset{(1.017)}{0.993}\begin{bmatrix} d,\ \text{Orange Avenue} - \\ \text{Commercial St.} \end{bmatrix} + \underset{(0.49)}{1.80}\begin{bmatrix} d,\ \text{Navy Base} \\ \text{access} \end{bmatrix} + \underset{(0.345)}{0.370}\begin{bmatrix} \text{Lot Area} - \\ \text{sq. ft.} \end{bmatrix} + \underset{(0.047)}{0.474}\,(\text{Property Value}_{1964}) - 10{,}937$ $R^2 = 0.72$ d.f. = 106 Where d = distance in feet
Clackamas County, Oregon Residential (Willamette River) †	$\Delta V = \underset{([illegible].272 \times 10^7)}{[illegible].485 \times 10^7}\left(\frac{1}{d,\ \text{water} + 1000} - 0.0007\right) + \underset{(0.392)}{0.459}\,(d,\ \text{park}) - \underset{(0.56)}{2.17}\,(d,\ \text{nearest school}) - \underset{(0.523)}{0.480}\,(d,\ \text{shopping center}) + \underset{(0.302)}{0.554}\,(d,\ \text{Portland}) + \underset{(0.022)}{0.149}\,(\text{Lot Area} - \text{sq. ft.}) - \underset{([illegible].071)}{[illegible].060}\,(\text{Property Value}_{1963}) + 844$ $R^2 = 0.41$ d.f. = 90 where d = distance in feet
Clackamas County, Oregon Rural Land (Willamette River) †	$\Delta V/\text{Acre} = \underset{(0.070 \times 10^7)}{0.354 \times 10^7}\left(\frac{1}{d,\ \text{water} + 500} - .00022\right) - \underset{(546)}{474}\,(d,\ \text{nearest boat ramp})\ \text{miles} - \underset{(128)}{261}\begin{bmatrix} d,\ \text{nearest bridge} \\ \text{access} \\ \text{miles} \end{bmatrix} - \underset{(140.9)}{50.4}\,(d,\ \text{nearest town}) + 2{,}58[illegible]$ $R^2 = 0.60$ d.f. = 29 where d = distance in feet
Charleston, W. Va. (Kanawha River) †	$\Delta V = \underset{([illegible] \times 10^5)}{[illegible]41 \times 10^5}\left(\frac{1}{d,\ \text{water}} - .0005\right) - \underset{(0.136)}{0.032}\begin{bmatrix} d,\ \text{bridge} \\ \text{access} \end{bmatrix} - \underset{(0.045)}{0.126}\,(\text{Property Value}_{1960}) + 2187$ $R^2 = 0.17$ d.f. = 61 where d = distance in feet
Dunbar, W. Va. (Kanawha River)	$\Delta V = \underset{(0.089 \times 10^6)}{0.101 \times 10^6}\left(\frac{1}{d,\ \text{water}} - .0005\right) + \underset{(1.096)}{0.784}\begin{bmatrix} d,\ \text{nearest} \\ \text{school} \end{bmatrix} + \underset{(0.364)}{0.089}\begin{bmatrix} d,\ \text{new highway} \\ \text{access} \end{bmatrix} + \underset{(0.439)}{0.662}\begin{bmatrix} \text{Lot Area} - \\ \text{sq. ft.} \end{bmatrix} - \underset{(0.150)}{0.538}\,(\text{Property Value}_{1960}) + 3324$ $R^2 = 0.4[illegible]$ d.f. = 23 where d = distance in feet
Beaver, Penn. (Ohio River)	$\Delta V = \underset{(1.136 \times 10^6)}{0.493 \times 10^6}\left(\frac{1}{d,\ \text{water}} - .0005\right) - \underset{(3.24)}{4.06}\begin{bmatrix} d,\ \text{State Street} - \\ \text{Commercial St.} \end{bmatrix} + \underset{(1.332)}{0.038}\,(d,\ \text{Agnew Sq.}) + \underset{(1.686)}{0.906}\begin{bmatrix} d,\ \text{Railroad} \\ \text{Station} \end{bmatrix} + \underset{(2.630)}{1.419}\,(d,\ \text{High School}) + \underset{(0.088)}{0.221}\,(\text{Property Value}_{1970}) - 6030$ $R^2 = 0.20$ d.f. = 46 where d = distance in feet

† The coefficient of the distance to water term is significant at the 95 percent level of confidence.

The terms in parenthesis below the coefficients are the standard errors of the coefficients.

ΔV includes capitalized value of change in taxes.

Table 8. POLLUTION ABATEMENT BENEFITS CALCULATED FROM PERCENT AND ABSOLUTE CHANGE REGRESSION EQUATIONS

Location	Percent Benefit Per Residence at Various Distances from the Water				Absolute Benefit Per Residence at Various Distances from Water (Dollars per Residence)			
	100 feet	500 feet	1000 feet	2000 feet	100 feet	500 feet	1000 feet	2000 feet
Coronado, Calif. (San Diego Bay)	8.2	7.4	6.3	4.2	4173	3745	3210	2140
Clackamas County, Oregon Residential (Willamette River)	24.9	16.7	10.7	4.6	3395	2280	1455	630
Clackamas County Oregon Rural Land (Willamette River)	65.4	39.7	20. 3	8.1	5075*	3080*	1575*	630*
Charleston, W. Va. (Kanawha River)	2.88	.45	.15	0	894	141	47	0
Dunbar, W. Va. (Kanawha River)	Inconclusive Regression Results							
Beaver, Penn. (Ohio River)	Inconclusive Regression Results							

*Dollars/Acre of land only.

RESULTS FOR RESIDENTIAL PROPERTY

The pollution abatement benefits are displayed graphically in Figures 7 and 8 for the three residential sites where the benefits were measurable. The benefits at San Diego Bay and the Willamette River are comparable. This comparability could be expected since there have been major changes in water quality at both sites, and interview results verified that property owners were aware of the water quality improvements. Moreover, the water quality changes themselves were similar, including increased dissolved oxygen, decreased fecal coliform counts, and a decrease in visual pollutants such as floating debris, scum, bottom sludge, and algae.

Results indicate that an existing parcel of residential property on the shore of San Diego Bay at Coronado experienced an 8.2 percent increase in value due to pollution abatement, while a house on the banks of the Willamette River near Portland probably experienced a 16 to 25 percent increase. The benefits decreased more rapidly with distance from the water at the Willamette River site than at Coronado. At 2000 feet from the water the benefit was 4 percent at the San Diego Bay site and about the same at the Willamette site. The difference in the size of the water bodies may explain the different rates of decrease in benefits with distance from the water. The sizable San Diego Bay dominates the Coronado site more than the Willamette River does the Clackamas County site.

If benefits are expressed in absolute terms as derived from the absolute value change model, the results are very nearly the same for San Diego Bay and the Willamette River (see Figure 8). For a residence 100 feet from the water, the benefit is $4,173 at San Diego Bay, and $3,395 on the Willamette River. If these absolute changes are converted to percentage changes using the value of an average home from the respective study samples, the results for both the bay and the river are nearly the same as those reported in Figure 7. In this sense, the results of our study were consistent.

On the Kanawha River at Charleston where water quality changes have been moderate and interview respondents were not in general agreement whether water quality had improved or worsened, the regression results indicated a significant but much smaller benefit. The pollution abatement raised river bank property values by about three percent and the impact decreased rapidly to zero at 2000 feet. Regressions for property value changes at Dunbar, about eight miles downstream from the Charleston site, were not statistically significant enough to justify drawing any conclusions about benefits from pollution abatement. Our inability to obtain significant results is certainly due in part to the moderate water quality change but may also be attributed to the way in which value changes were measured. Assessed values were used to calculate 1968 property values, which were in turn inflated to 1970 values. Actual sales records were used for 1960 sales prices. Although the assessments from which the 1968 property values were derived were very good, it is conceivable that more time is needed before the water quality improvements are reflected in assessed values, than for the impact to be felt on sales prices. Since assessors use sales data to compute their assessments, sales prices must increase before assessed values can increase. For the more successful sites, we carried out calculations using assessed values to estimate property value before the water quality improvement and actual sales prices for 1970 values. Inconsistencies in 1960 tax assessments at the

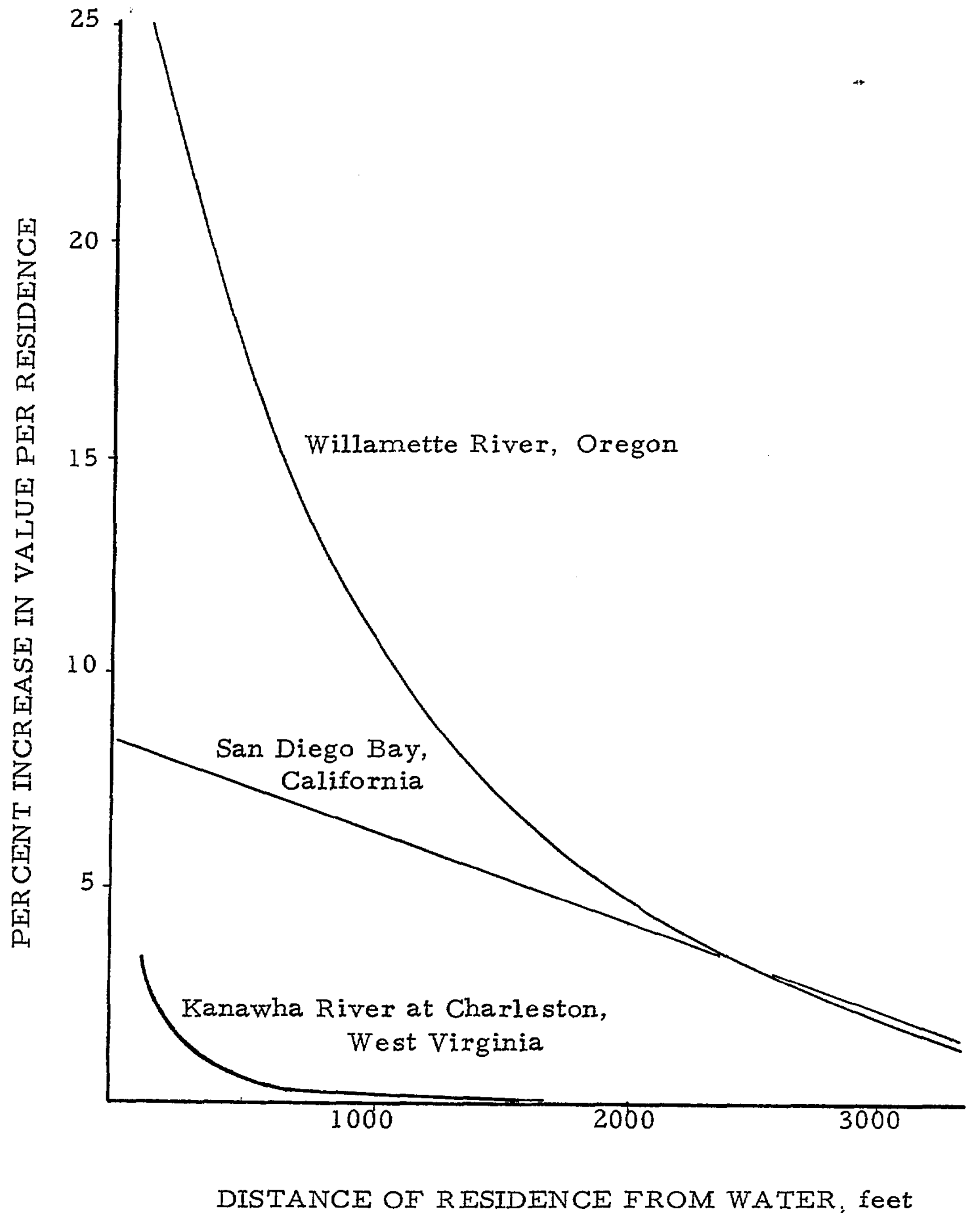

Figure 7.

BENEFIT OF POLLUTION ABATEMENT EXPRESSED AS PERCENTAGE OF RESIDENTIAL PROPERTY VALUE

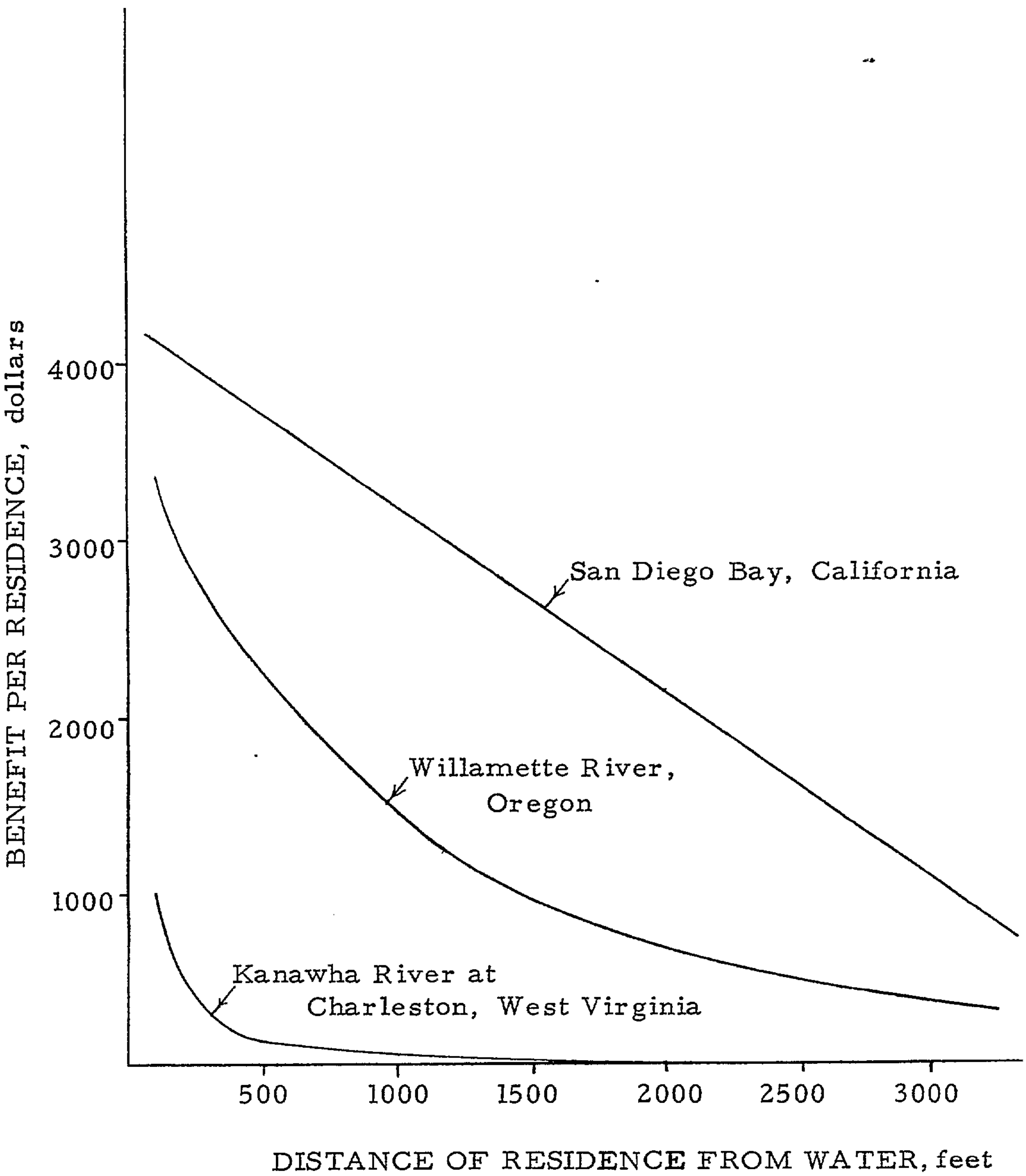

Figure 8

BENEFIT OF POLLUTION ABATEMENT EXPRESSED AS DOLLAR INCREASE PER SINGLE-FAMILY RESIDENCE

Kanawha River sites precluded our using this method there.

Results of the analysis for the Beaver site were also inconclusive, probably because the water improvement impacts were too small to be detected. Moreover, there is no direct river access, and the residential properties studied are all situated at the top of a steep, 60-foot-high bank. The location is a scenic non-industrial part of the Ohio River, and residents' enjoyment of the river is primarily aesthetic. Although the people know the river has improved, the chemical changes in the water (higher dissolved oxygen, higher pH, and lower specific conductivity) are not readily apparent and therefore have little or no tangible effect on property values on the high bank. Finally, the moderate changes in water quality affect the quality of the river view at Beaver very little.

We may be able to draw one conclusion about the different influences of rivers, bays, or lakes on the basis of our site studies and extensive observation. A comparison of the Willamette River and San Diego Bay, where water quality changes were similar, indicates that while the property value benefits to properties adjacent to the water are larger for the river than for the bay, the benefits from the bay decrease less rapidly with increasing distance from the water's edge. In other words, because the bay is a dominant geographic factor, its quality changes seem to have a smaller but more extensive influence on property values.

RURAL SITE

If rural land has potential uses which are affected by water quality such as for homesites or recreation sites, then pollution abatement can be expected to raise the market value of this land. If the only uses are agricultural, then water quality improvement will raise land values only if agricultural productivity depends on water quality (irrigation, for example).

A substantial benefit was measured for the rural land along the Willamette River near Portland. For the sample tested, the percent change model attributed a 65.4 percent increase in value to water-proximate land, while the absolute value model attributed a gain of $5,075 per acre on land with an average value of $4,585 per acre in 1960 (equivalent to a 110 percent increase). Both of these increases apply only to land within 100 feet of the water. The benefit decreases rapidly with distance from the water, reaching zero at 4000 feet.

In the rural Willamette Valley site, there is definitely an increasing demand for vacant land for homesites and parks. All land values in the sample almost doubled from 1960 to 1970. Since both rural and urban respondents in the Valley are moreover aware of the Willamette's improved condition, the benefit calculations seem reasonable. These calculations say in effect that, based on average 1960 prices, the expected 1970 benefit from pollution abatement was a 65 to 110 percent increase in value for waterfront land. The first figure derives from the percent value change model and the second from the absolute change model. The higher absolute change model results were more significant statistically.

Although the analysis showed that impact of water quality changes on rural land values can be expressed as a continuous function of distance from the water, a very high correlation was also found using only a waterfront dummy variable with no distance term. This indicates that benefit is greatly dependent on the land offering actual water access in addition to proximity.

In the last part of this study, the results of the case studies were used as guidelines to calculate the national benefit of pollution abatement on property values. How the calculation was accomplished is described in Section VI.

Section V

Water Quality

The first portion of this study measured the increase in property values attributable to improvements in water quality. Very little was said about the factors which contribute to people's perception of water quality, or the physical parameters which determine that quality.

Quantification of water quality changes is not a necessary prerequisite to measuring the impacts of the changes at each of our study sites, because the water quality change is the same for all properties within each study site.

It was our original intention to conduct personal surveys of peoples' attitudes towards the various aspects of water quality and to combine the results with technical knowledge of water properties to create an index relating changes in property value to changes in the most frequently measured water quality parameters. Such an index would allow comparison between sites and prediction of the property value benefits of various degrees of pollution abatement on the basis of recorded data on presently polluted water throughout the country. However, we did not develop a new index; this effort had to be abandoned when it became clear that the technical data necessary to define and use such an index was lacking. Measurements for the many parameters required to derive a meaningful index are not collected and recorded systematically or at enough places for us to do a useful analysis.

We did use the results of our interview to verify the relationship between peoples' awareness of water quality changes at each site and tangible impacts on property values which we measured using regression analysis. The results of this effort were described in Section IV, under "Perception of Water Quality Changes." We also accomplished the important task of isolating the principal utility aspects of residential property owners' valuation of the quality of a proximate water body. We can judge which directly measured water parameters are important by knowing what measurable properties of water are the important determinants of suitability for each use. For example, if swimming is a very important water use and bacteria concentrations (fecal coliform counts) are the primary determinant of whether or not water is safe to swim in, then we can conclude that fecal coliform counts are an important determinant of “water quality.” In the remainder of this section we will explain which principal uses determine resident valuations of a water body, which directly measured water parameters determine the suitability of water for each use, and how we measured the relative importance of each use to property owners.

From the standpoint of a residential property owner, there are basically three preceptible aspects or utilities for a proximate water resource’s quality or value: aesthetics, wildlife support capacity, and recreational potential. The aesthetic value of a river or lake is a measure of how pleasing the water body is to look at or be near. It is important to note in passing that the aesthetic value of a river or lake is determined as much or more by the condition of the bank or shoreline as by the quality of the water [2]. For example, the Hudson River Valley may be most beautiful in the fall when the trees are changing color although water conditions are the worst at this time of year due to low flows and high temperatures. The combination of water quality and the quality or character of the interface between land and water accounts for the total aesthetic value of a water resource.

However, in this study our concern is with the quality of the water. All the study sites were deliberately selected in places where the area around the water is scenic, uncluttered, and non-industrial, so that water quality was the major determinant of changes in water resource impacts. The aesthetic value of the *water* alone is a product of its color, clarity, odor, the amount of debris floating on its surface or visible on the bottom and shore, and any floating oil, scum, foam, or sludge.

Pure water is colorless. Whatever color water appears to have is due to dissolved impurities, suspended solids, bottom coloration, or reflected light. Usually, if the coloration is due to human activities, it is the product of suspended solids producing muddy, turbid water or an overabundance of green, brown, or red algae. Both affect the clarity or turbidity of the water as well as the color. Therefore, when referring to water pollution levels, clarity and water color are highly correlated.

Water clarity can be measured. A popular and meaningful measure of water clarity is the Secchi disk method: an eight-inch diameter white disk is lowered into the water and by a controlled procedure, the maximum depth at which it is visible is measured.

Odor is another important determinant of aesthetic value. Numerous impurities impart odor to water; some odors result from waste discharges while others may be natural. Most commonly, persistent disagreeable odors are due to anaerobic biological activity which takes place when dissolved oxygen concentrations are depleted by oxygen demanding municipal and industrial waste loads. Although odor seems to be a difficult parameter to measure in any objective manner because of individual variations in tastes and sensitivity, there is at least one widely accepted, straightforward measure of odor intensity. This is the threshold odor number. The threshold odor number of a water sample is equal to 2^N where N is the number of times the sample must be diluted (with odorless water) before it has no detectable odor. While this test does not account for the nature of the odor or its cause, it is sensitive to the tester's olfactory senses as well as inexpensive to perform and easily interpreted.

Visible pollutants such as cans, bottles, or paper on the water surface or bottom as well as unnatural oil, scum, and sludge are also important determinants of water appearance and aesthetic value but, unfortunately, standard objective measures of these nuisances are not in common usage and remain badly needed for meaningful measurement of pollution trends [12].

In addition to aesthetics, water bodies of all types are also valuable by virtue of the fact that they constitute the natural habitat of numerous species of fish, birds, and other living things. These aquatic creatures provide man with food and recreation, as well as psychic pleasure. Needless to say, water quality is an important factor in the wildlife support capacity of a water body. We know of only one effort to relate water quality parameters to the water's fitness for wildlife. Research was conducted with the National Sanitation Foundation to develop a water quality index specifically for fish and wildlife [3]. The index (called the FAWL Index) is based on the judgment of a large group of professional water quality managers. Using a modified Delphi (interview) technique, nine water quality parameters were selected and weighted to indicate how healthy a fresh water body is for all life forms. The nine water parameters in order of their importance in the judgment of these experts are dissolved oxygen, temperature, pH, phenols, turbidity, ammonia, dissolved solids, nitrates, and phosphates. The weightings of the parameters are the following (the weights have a sum of unity):

Parameter	**Weight**
Dissolved Oxygen	.206
Temperature	.169
pH	.142
Phenols	.099
Turbidity	.088
Ammonia	.084
Dissolved Solids	.074
Nitrate	.074
Phosphate	.064

People also value water for its recreational potential, such as boating, fishing, and swimming. Although the recreational potential of any water body also depends on access and on facilities such as boat ramps or beaches with life guards, it is determined largely by water quality. Water quality is most critical for swimming. The Committee on Water Quality Criteria recommended that fecal coliform count should be used as the indicator organism for evaluating the microbiological suitability of recreational waters [1].

For primary contact recreation (activity where there is a significant risk of water ingestion) the Committee recommended that fecal coliform counts shall neither exceed a log mean of 200/100 ml, nor shall more than 10 percent of total samples during any 30 day period exceed 400/100 ml. The Committee also recommended that the pH should be within the range of 6.5 to 8.3 except when due to natural causes. and that in no case shall it be less than 5.0 or more than 9.0. In addition, the Committee suggested that the clarity of primary contact waters should be such that a Secchi disk is visible at a minimum depth of 4 feet, and that the maximum water temperature should not exceed 85 degrees F. For other than primary contact recreation, such as boating or fishing, the Committee recommended that fecal coliform content should neither exceed a log mean of 1000/100 ml, nor exceed 2000/100 ml in more than 10 percent of the samples, and that for fishing to be a suitable activity, conditions which are healthy for fish and wildlife prevail. In summary then, fecal coliforms and pH along with the parameters which determine suitability of water for wildlife, are the important water quality determinants of recreation potential.

Aesthetics, wildlife support capacity, and recreational potential are by no means independent attributes of a water body. It is difficult to conceive of conditions where a natural body of water is aesthetically pleasing and good for boating and swimming, yet still unfit as a wildlife habitat. Nonetheless, the three attributes are independent and recognizable enough that it is useful and convenient to think of the total value of a water resource as the sum of its aesthetic value, wildlife support value, and recreation value.

Some of the people who bought homes at our study sites valued the water enough to pay more to live near it, and we have measured the value they place on the total change in water quality in terms of changes in property values. We employed an interview technique to determine further the relative importance of each of the three aspects of water utility described above to the owners of nearby residential properties.

We interviewed a random sample of 160 residential property owners (40 at each of 4 locations) at their homes. The text of the personal interview is contained in Appendix I. Questions 1 through 9 deal with value assessments. The sample of property owners was selected from within the urban and rural study sites on the Willamette River in Oregon, the site on San Diego Bay, and the Kanawha River sites. Within the site boundaries the samples are distributed randomly with respect to distance to the water, that is, some respondents live at the water's edge and others live as far as 4000 feet away from the water. The sample was divided evenly between males and females. All respondents said they had participated in the decision to buy their home, but no two respondents lived at the same address.

Each respondent was asked to distribute 100 votes between three categories of water capability, aesthetics, wildlife support, and recreation opportunity, in a manner which would reflect their personal feelings about the relative value of each. Subsequently, respondents were asked to distribute another 100 votes within the aesthetics category between water clarity, color, odor, and floating debris or oil, in terms of their importance as aspects of water appearance and attractiveness.

Before voting, respondents were asked to imagine themselves in a hypothetical situation where the water attributes were mutually exclusive, and make a pair-by-pair choice between the three water attributes. Within this hypothetical framework most respondents said they preferred improvement of wildlife support capacity to both recreation opportunity and appearance. The choice between water appearance and recreation was more difficult. but the majority of the respondents preferred measures to improve appearance. The hypothetical situations were posed prior to vote casting to help define the attributes and give respondents an opportunity to think about the ordering of their personal preferences.

The results of the vote casting are presented site by site in Table 9. The cumulative result of the value assessment is presented more graphically in the pie chart depicted in Figure 9. Wildlife support accounted for 49.3 percent of the total value of a water resource. Since fish are wildlife, respondents were asked to use their votes in the wildlife category to include their evaluation of fishing (46 percent of respondents said they had been fishing within the last two years). Of the remaining votes, appearance (aesthetics), swimming, and boating accounted for 26, 6, 13.9, and 10.2 percent, respectively. The outcome of the voting seems to indicate that property owners are most concerned with making water fit for wildlife. If boating and swimming are lumped together under the label, recreation, then people weigh the importance of recreation and appearance about equally.

In designing our survey questionnaire, we sought to render the voting categories as mutually independent as possible in order to preclude ambiguous responses. Therefore, although a given water capacity might have relevance to more than one utility category, it was necessary to assign it to a single one. Fishing and picnicking are both forms of recreation; however, the possibility for their enjoyment is primarily determined by water quality conditions under the wildlife support capacity and aesthetic categories. That is, fishing is impossible where there are no fish. Similarly, picnicking is not feasible where aesthetic deterioration has rendered the water body unpleasant. Therefore. our respondents were asked to evaluate fishing under the wildlife support category, and picnicking as a facet of aesthetics. Boating and swimming remained as the primary recreational activities whose feasibility was separable from the other two categories.

The cumulative result of the distribution of 100 votes among the aesthetic or appearance aspects of water was 36.6 percent weight on the absence of floating debris and oil, 25.7 percent weight on odor, 27.7 percent on clarity, and 10 percent on color. Thus, of the factors influencing aesthetics, trash and debris take precedence over odor and water clarity or color.

There is no substantial difference among average responses for different sites. All are remarkably similar in their ordering and weighting of water attributes. Responses for men and women were also remarkably similar with no clearly recognizable differences. The average age of respondents was between 45 and 60 years, with only eleven percent under 30.

When asked, 75 percent of the people interviewed replied that the voting system did let them accurately express their feelings about the various aspects of water attractiveness and appearance. When respondents were dissatisfied with the voting system, the reasons most frequently offered were: “the choices are not specific enough or are too limited;” “the choices overlap, or are not mutually exclusive;" “color and clearness of water are the same thing;” “my feelings depend upon whether the water condition was natural or affected by man.” Some people simply needed more time than our interview offered to respond. While these criticisms are certainly valid in the abstract, given the complexity of interdependencies between water attributes and the administrative ease aimed at in our

	Sample Size	Percentage	Q. 11 If you had 100 votes, how would you distribute them among these categories of water quality in terms of importance to you?				Q. 12 If you had 100 votes, how would you distribute them among these aspects of water appearance and attractiveness in terms of importance to you?			
			APPEARANCE	WILDLIFE	BOATING	SWIMMING	COLOR	ODOR	CLEARNESS	ABSENCE OF DEBRIS
WILLAMETTE RIVER - URBAN -		100 80 60 40 20 0	19	55	11	15	15	25	25	35
WILLAMETTE RIVER - RURAL -		100 80 60 40 20 0	31	39	12	18	8	29	26	37
SAN DIEGO BAY		100 80 60 40 20 0	26	51	9	14	10	20	32	38
KANAWHA RIVER		100 80 60 40 20 0	31	52	9	8	7	29	32	38
CUMULATIVE		100 80 60 40 20 0	27	49	10	14	10	26	28	36

TABLE 9 - WATER QUALITY ASPECT

VALUE ASSESSMENT

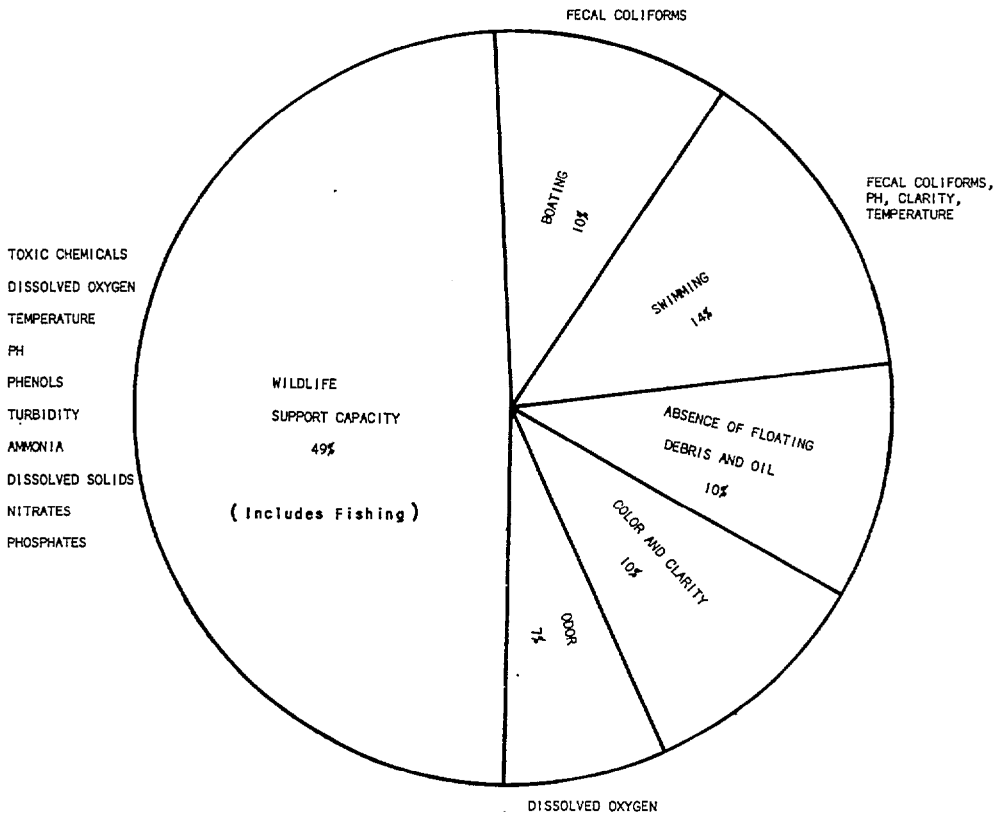

Figure 9 - THE RELATIVE VALUES OF WATER QUALITY ASPECTS AND IMPORTANT WATER PARAMETERS WHICH DETERMINE THE SUITABILITY FOR EACH PURPOSE.

questionnaire, the results are remarkably consistent and yield considerable insight into what determines the value of a major water body for nearby property owners.

CONCLUSIONS

Figure 9 displays the relative importance of the different water quality aspects together with the important water parameters which determine each aspect. An examination of this figure reveals which water parameters are most important in determining how property owners perceive water quality and how water quality affects property values in turn. As we have seen, the most important water aspect for the property owners sampled is wildlife support capacity and the primary determinants of this capacity are toxic chemicals, dissolved oxygen, temperature, and pH. The suitability of a water body for swimming and boating activities is determined by fecal coliform concentration, pH, clarity, and temperature. The aesthetic value of water depends largely on clarity, absence of floating debris and oil, and odor (usually a function of dissolved oxygen concentration). Thus, the most important direct measures of water quality as it is perceived by nearby property owners are toxic chemicals, dissolved oxygen, fecal coliforms, clarity, trash and debris, and pH. The list is roughly in order of importance. These measurable components of water quality are the principal determinants of how residential property owners at our case study sites rate the value of their resource.

We drew no direct quantitative link between people's perception and the measures of water quality and the results of our regression analyses at the six sites where water quality has changed. The interview results and regression results are nonetheless mutually supportive. At San Diego Bay and the Willamette River, where there were substantial changes in dissolved oxygen concentrations, fecal coliform concentrations, water clarity, and visual pollutants, we also measured substantial benefits. In contrast, on the Kanawha River where the only perceptible change was in the amount of visual pollutants (oil and debris), measured benefits were small at the Charleston site while the regression results at Dunbar were inconclusive. Regression results were also inconclusive at Beaver, Pennsylvania, where measured changes in the dissolved oxygen, specific conductivity, and pH of the Ohio River produced no major changes in recreation usage, appearance, or wildlife support capacity. Together, these results support the hypothesis that significant changes in the water parameters which our interview results determined to be of primary importance do produce large changes in property values.

The possibility of correcting those pollution components which are of greatest importance to residential property owners, and therefore of realizing benefits in property value increases, is very good. Pollution manifested as low oxygen, high fecal coliform counts, or high concentrations of toxic chemicals is correctable by improving municipal and industrial waste treatment. Trash, debris, and other visual pollutants are also controllable. Since floating debris and other visual pollutants comprise a full third of the detriment to a water body's aesthetic value according to our interview responses, cleaning up trash and debris on a badly littered river reach alone might increase property values measurably. Lack of water clarity due to algae blooms is correctable if the algae concentrations are due to over-enrichment of the water by waste discharges. Poor clarity or equivalently high turbidity due to rapid water run-off and soil erosion are much more difficult to control, as is low pH due to acidic drainage from abandoned coal mines, a condition prevalent in the Ohio River Basin.

During the course of this project several shortcomings in present pollution trends analysis have become apparent. To measure progress in water pollution abatement as it is perceived by the public, the important parameters listed earlier should be measured primarily at places and during periods when problems are known to exist, such as downstream of population and industrial concentrations during low flow summer months. Historically, however, water monitoring has been done upstream of waste discharges at municipal water intakes and at dam sites or water works where it is convenient. Water body flow characteristics and waste discharge patterns should be given more consideration in the design of water monitoring programs. While the parameters most widely and routinely monitored are those which are easy to measure or important to public water suppliers or geologists, more attention should be given to those which reflect the condition of the water as it is perceived by the public (dissolved oxygen, fecal coliforms, clarity, floating debris and oil, and toxic chemicals). Good dissolved oxygen, fecal coliform, and clarity measurements are far too scarce. The number of water samples taken for each measurement and the number or frequency of measurements should be no fewer than the minimum required to achieve some reasonable degree of statistical significance. Data taken only once a month, for example, is virtually worthless for observing pollution trends because of variations in readings due to routine measurement error and daily and yearly fluctuations in discharges and weather. It also is helpful to interpretation to have the data presented as cumulative frequency distributions, that is, in terms of the percentage of measurements which exceeded critical quality criteria.

Section VI

National Benefit of Water Pollution Control on Property Values

We can now estimate the national benefit of water pollution control using the results of the case studies as guidelines and data on the incidence of water pollution in the contiguous United States. We will make low, medium, and high estimates of the total property value increase attainable by bringing all waters in the nation to a condition which will support desirable life forms, permit desired practical water uses, and which is aesthetically pleasant. The high and low estimates are necessarily based on extreme assumptions and are intended to define the range within which the actual benefit can reasonably be expected to be. The medium value represents our best estimate of what the benefit will be on the basis of all available information.

The estimated benefit is the expected increase in the values of existing residential and recreational property which will result from pollution abatement. Potential increases in the values of land now occupied by industry, highways, or railroads, and the value of future developments which might become feasible after pollution abatement are not considered.

Extrapolating from a limited number of successful case study results to an estimate at the national level is beset with many problems. One major difficulty stems from the fact that data limitations or on-site characteristics constrained us to a very narrow sample of geographic areas, types of water bodies, and water quality changes upon which to base our estimate. Consequently we have to rely on subjective assessments of many important relationships and parameters. One such fundamental relationship is that between potential property value increases and the pollution level measures which are available nationally. In addition. the poor quality of information about the location, character, and intensity of water pollution makes a great deal of guesswork necessary to reconstruct a nationwide picture of water pollution and this in turn introduces a high level of uncertainty. Many simplifying assumptions are necessary due to the great magnitude of the task of inventorying property affected by water pollution. In the description that follows we have explained our methodology and assumptions as clearly as possible in order to make our estimate useful as a base for future work. We have also included whatever unequivocal supportive evidence exists and related the sensitivity of our national benefit estimate to variations in those assumptions for which there is the weakest support.

LOCATION OF POLLUTED WATERS AND INTENSITY OF WATER POLLUTION

The first step in measuring the national benefit of pollution abatement is to determine the locations of all polluted water bodies which are large enough to influence property values and also to determine the intensity and duration of the pollution at each location.

The Environmental Protection Agency has conducted two national water pollution inventories (the 1970 and 1971 PDI surveys) to measure the prevalence, duration, and intensity of pollution within each of the 241 minor drainage basins within the fifteen major drainage basins. A river reach or shoreline was classified as polluted and labelled a "pollution zone" for inventory purposes if it was consistently or recurrently out of compliance with one or more of the legal water quality criteria. For each pollution zone the annual duration of pollution was measured in terms of the number of quarter-year periods or seasons in which it occurs. Values from 0 to 1 were assigned to a duration index, D, as follows [10] :

- 0.4 for violations occurring within 91 consecutive days.
- 0.6 for violations occurring within a period greater than or equal to 93 consecutive days, but less than or equal to 183 consecutive days.
- 0.8 for violations occurring within a period greater than 183 consecutive days, but less than or equal to 274 consecutive days.
- 1.0 for violations occurring in all four quarters within a period greater than 274 consecutive days.

The intensity of pollution in a specific pollution zone was measured in terms of its effects rather than in terms of water quality parameters. An intensity index, I, was assigned to each pollution zone. The value of I ranges from 0 to 1 and represents the simple addition of the values assigned to three component measures which classify impacts according to ecological, utilitarian, and aesthetic considerations. Ecological impacts include the effects of pollution on the existence or the potential for existence of desirable life forms, including man. Pollution effects causing reductions in the economic or resource utilization values of the water (including boating and swimming) are grouped under utilitarian impacts. Lastly, pollution effects disagreeable to the senses are included in the category of aesthetics. The value scale for each of these components follows [11]:

Ecological

0.1 = conditions that threaten stress of life forms (including sanitary aspects not related to any verifiable instances of contagions).

0.2 = conditions that produce stress on indigenous life forms.

0.3 = conditions that reduce productivity of indigenous life forms.
0.4 = conditions that inhibit normal life processes or threaten elimination of indigenous life forms.
0.5 = conditions that eliminate one or more indigenous life forms.

Utilitarian
0.1 = conditions that require costs above the norm to realize legally defined (i.e., in water quality standards) uses.
0.2 = conditions that intermittently inhibit realization of some desired and practical uses or necessitate use of an alternate source.
0.3 = conditions which frequently or continually prevent the realization of desired and practical uses or cause physical damage to facilities.

Aesthetic
0.1 = visually unpleasant.
0.2 = visually unpleasant with association of unpleasant tastes or odors.

The maximum weightings for each impact category agree well with the weightings we determined through personal interviews for our categories of wildlife support capacity (.49), recreational potential (.24), and aesthetics (.27). The correlation between our wildlife support capacity value and the EPA "ecological" value is almost exact, while the correlations between the weightings our respondents gave to our recreation potential and aesthetics categories and the relative weightings of the EPA "utilitarian" and "aesthetic" categories are very close. Since our interviews aimed at determining the relative importance of the different aspects to the single-family home owner's total valuation of water quality, the agreement between our respondents' weightings and those of the EPA intensity index effect categories indicates that the intensity index, I, is a good measure of pollution as it affects residential property values.

The duration, D, and intensity, I, indices for different localities were assigned by teams of EPA staff members familiar with legally-established water quality criteria and uses, water quality data, and local ecological patterns. Results of local pollution assessments were summarized by the EPA and an average duration-intensity index (DI) was computed using the following formula:

$$DI = \frac{\sum_{i}^{n} P_i D_i I_i}{\sum P_i}$$

where

P_i = Pollution prevalence, i.e., length in miles of pollution zone i. (River miles or shoreline miles)
D_i = Duration index for pollution zone i.
I_i = Intensity of pollution for pollution zone i.
n = Number of pollution zones in a basin.

Some interesting patterns were apparent when the EPA summarized duration and intensity indices and pollution for the nation. There are 260,324 stream miles in the contiguous United States. The 1971 PDI Survey indicated that 76,299 miles, or 29 percent, are polluted and of these polluted miles, 57,741, or 22 percent, lie in minor drainage basins, where the average DI factor is .2 or greater. Three major drainage systems (the Ohio River, the South Atlantic watershed, and the Great Lakes Basin) contain 23.9 percent of the nation's stream miles, but 48.9 percent of the polluted stream miles. Extensive pollution and high DI factors are generally limited to the Ohio, Great Lakes, Tennessee and North and South Atlantic watersheds. The boundaries of the major water systems are shown on the map of Figure 10. Data on total stream miles, number of polluted stream miles, average duration-intensity factor, and percentage contribution of major pollution sources (municipal, industrial, and federal installations, agricultural and rural wastes, mining wastes, water resources development, and transportation) are available for all 241 minor drainage areas from the 1971 DPI Survey. This summary data has been compiled and published [11]. Although we sought more disaggregated data for all polluted minor basins, we were able to obtain the raw data from which the summaries were compiled (maps plotting pollution zones, and tables recording exact polluted river miles) for only one important water system, the Great Lakes Basin. For this basin, we were able to determine exactly which river reaches and shorelines were considered polluted, and we could also determine their estimated DI factors.

For other minor basins, we relied on the PDI Survey summary data, our experience from mapping the Great Lakes data, water quality data from a variety of sources, and our own judgment to locate polluted water bodies. Water run-off patterns and areas of concentrated population and industry were easily discernible on large-scale topographic maps. Given the amount of stream miles that were considered polluted (from PDI summary data) and the sources of the pollution, it was possible for us to select and mark the waters which are most likely polluted. Most pollutants significant to determining property benefits emanate from fixed discharge points, such as municipal sewage treatment plants or industrial waste discharges, and the most probable locations of these sources can be deduced from the basin topography and the distribution of population and transportation systems. The average DI factor for each minor basin was assumed to apply uniformly to all polluted water within the basin unless other information justified assigning pollution intensity levels more selectively. We gained considerable insight into the general distribution of water pollution throughout the country, as well as some detailed information about specific water bodies in the early phases of this study, when we were searching for sites where water quality had changed. We put much of this experience and information to good use reconstructing the PDI survey in several areas. Our basic approach in locating and marking polluted reaches was conservative. No water body was marked as polluted unless there was some evidence to indicate that it was. Small tributary streams considered to have little positive effect on property values, were generally neglected, although there was occasionally reason to believe that some of these small tributaries were polluted, particularly in coal mining areas where acid drainage is a problem. Minor basins with an average DI factor of .2 or less were neglected because these moderate pollution levels would have only small impacts on property values, and therefore their contribution to accuracy of the national benefit estimate did not justify their measurement costs. Minor basins where the average DI factor was greater than .2 and upon which benefit measurements were based are shaded on the map of Figure 11.

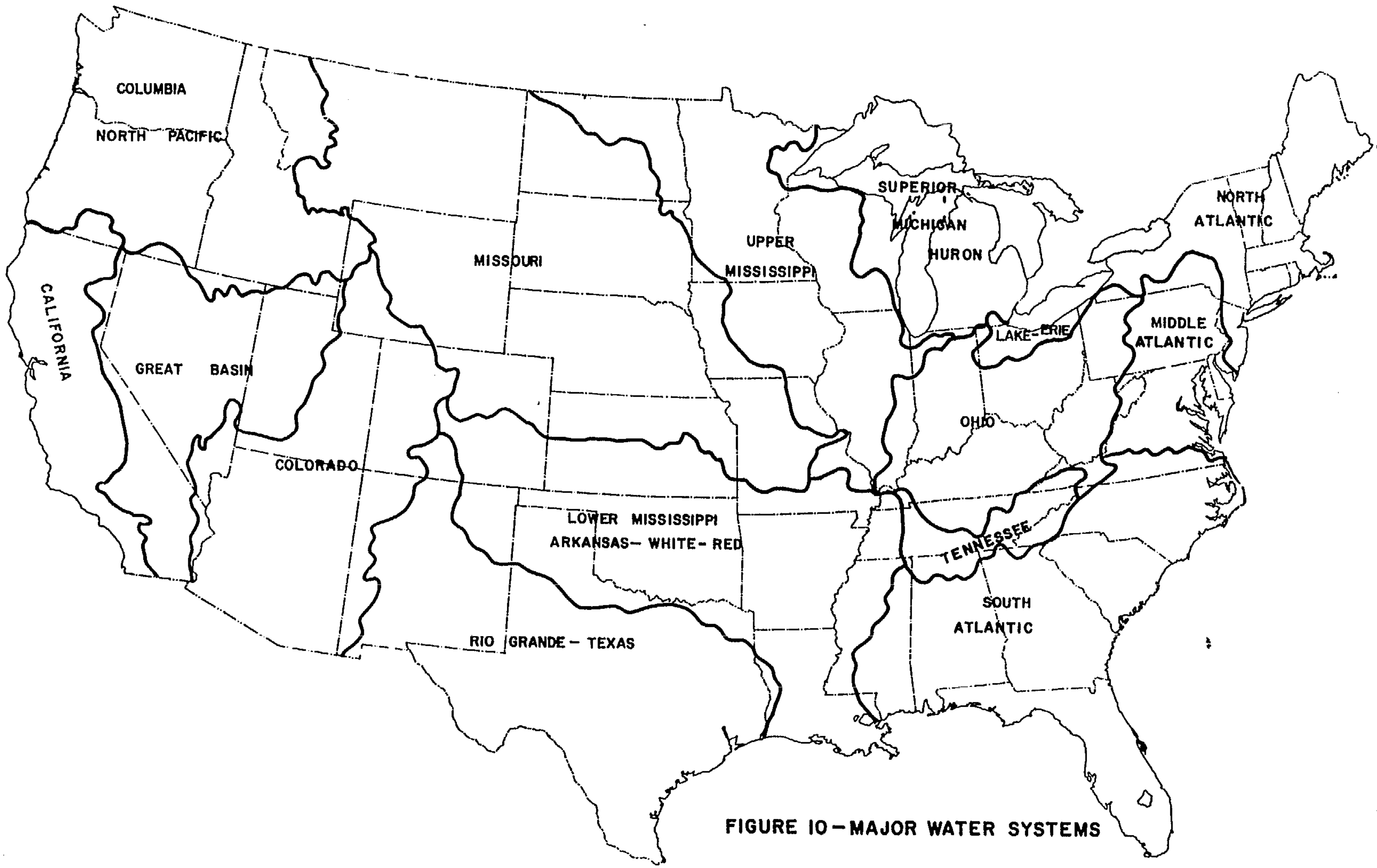

FIGURE 10—MAJOR WATER SYSTEMS

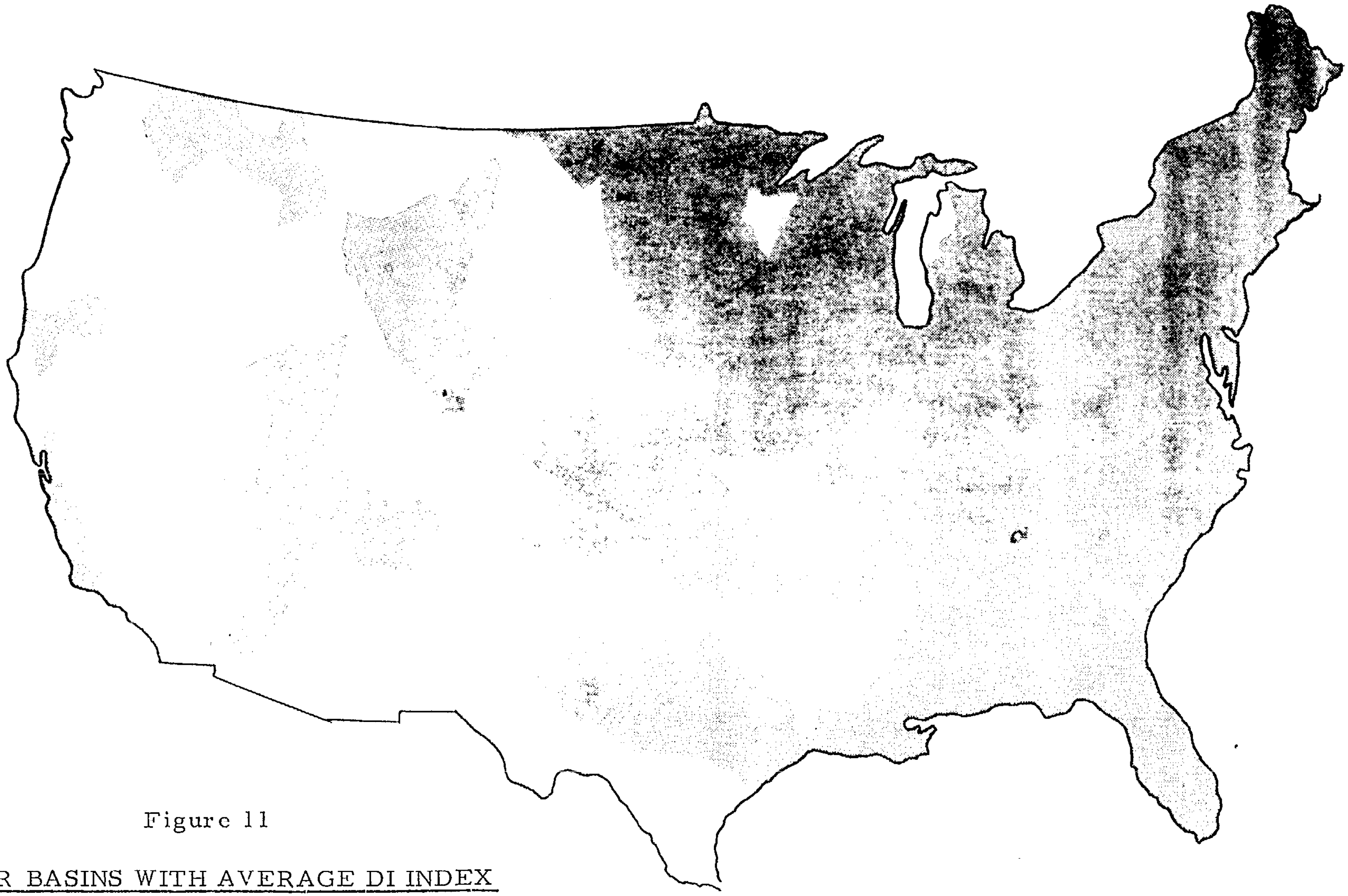

Figure 11

MINOR BASINS WITH AVERAGE DI INDEX GREATER THAN .2 (SHADED AREA)

Using the methods and assumptions just described we marked all polluted or "most likely polluted" river reaches and shorelines on U.S. Geological Survey topographic maps (1:250,000-scale series, a scale of approximately four miles to the inch). These maps which are available for the entire country except Alaska, show the extent of urban areas, political boundaries, roads, railroads, surface water, swampy areas, levees, and sometimes ground cover, as well as topography (200-foot contour interval). Mountainous areas, flood plains of major rivers, and general land use are discernible on these maps. This set of maps upon which we marked polluted water bodies and pollution intensity formed the base from which the national property benefit of pollution abatement was measured.

RELATIONSHIP BETWEEN BENEFIT AND THE DURATION-INTENSITY FACTOR

Before we can calculate how much existing residential, recreational, and rural property values will increase if water pollution is reduced to levels which will support desirable life forms and practical water uses and where the water is aesthetically agreeable (that is, where the DI factor approaches zero), we must establish an appropriate relationship between the pollution duration-intensity factor (DI) and benefits.

Our interview results indicated that the I factor was a good measure of pollution as it affects residential property values. On the basis of our case studies. however. we have no way of similarly validating the D factor. Nonetheless, the pollution inventory results are only available in terms of the DI index. The D factor is relatively less important than the I because in most cases intense pollution conditions do occur during the summer months, when people in most parts of the nation are most aware of water quality. Since multiplying the intensity factor, I, by the duration Factor, D, to compute the DI index attenuates the intensity factor, we can only guess that the resultant DI index will underestimate the pollution level perceived by property owners. This understatement will in turn render our national property value benefits estimate conservative. The heavy solid curve (Figure 12) represents our best estimate of the correct relationship between urban residential property benefit and the DI factor, with benefit expressed as the maximum percentage increase in an urban residential property located 100 feet from the water's edge. This curve applies to what might be considered as average local circumstances. The results of many more than five case studies would be necessary to give this curve precise meaning. However, we can base our selection of this curve on the insight we have gained from our case results into the relationship between the DI factor and the benefit impact. As we have drawn it, the curve has two important characteristics: (1) the curve increases rapidly with increasing DI ratings, and (2) rather than continuing to increase rapidly above DI ratings of about .5, the curve levels off to an approximate maximum 18 percent change in property value. Our earlier assumption that improvements to water with a DI of less than .2 would produce little property value benefit is also consistent with the behavior of this curve. We performed all our calculations of the national benefit from pollution abatement on the basis of this curve's shape. We moved or scaled the curve so that its maximum benefit point coincided with a 30 percent or 10 percent increase, in order to obtain the "high" and "low" benefit estimates discussed later. The dotted curves in Figure 12 represent the "high" and "low" estimate relations. The relationship between the maximum height of this curve and the metropolitan area and town components of the national benefit estimate is linear (changes in these components of the benefit

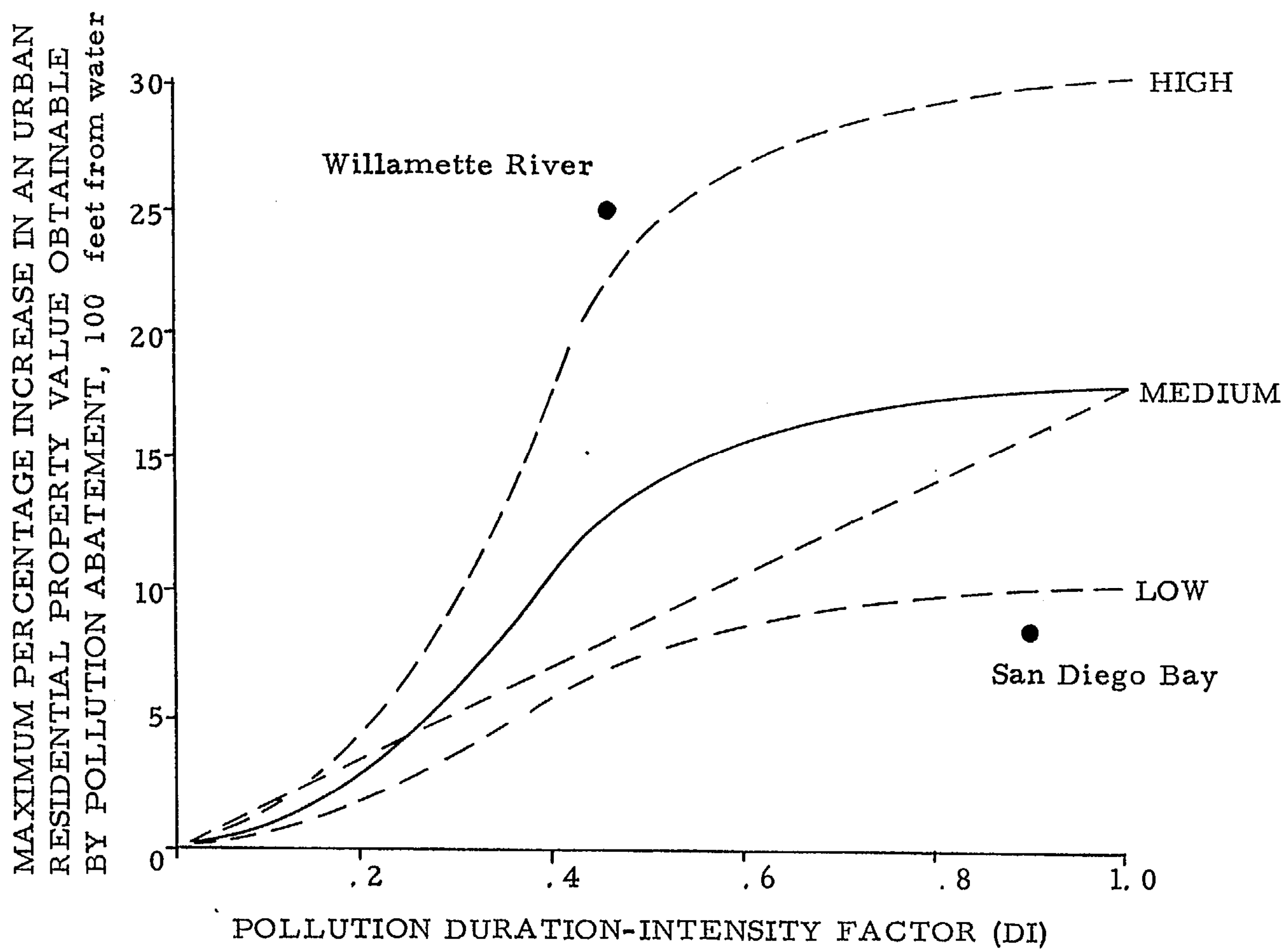

Figure 12

RELATIONSHIP BETWEEN POLLUTION INTENSITY AND MAXIMUM PROPERTY VALUE INCREASE OBTAINABLE BY POLLUTION ABATEMENT estimate are directly proportional to changes in the height of the curve).

Among our case studies are two urban sites where pollution started at high levels as measured by the DI factor, and was reduced to DI levels near zero. These are Coronado (San Diego Bay) and the residential site on the Willamette River in Oregon. On San Diego Bay serious pollution prevailed year-round, with 1960 pre-clean-up levels which would have merited a DI factor rating of .8 to 1.0, if computed. Critical water quality conditions on the lower Willamette River prevailed only during the low-flow summer months, so the appropriate duration index before clean-up was probably .4 or .6, with an intensity index of .8 to 1.0. Thus the approximated DI ratings (the product of D and I) on the Willamette River changed from somewhere in the range of .32 to .6 in 1960. to zero by 1970.

The results for Coronado and the Willamette River urban site (percent change models) are plotted in their estimated position in Figure 12. These are the only results that can meaningfully be plotted on this graph because these are the only sites where the latest water quality levels approach a DI of zero. The two points plotted are consistent with our speculations about the relationship of the results measured at the study sites and the quality changes in their respective water bodies, and their comparison with typical residential property near other polluted water bodies throughout the nation. Notice that if the horizontal axis were pollution intensity, I, only, the point for the Willamette River results would be well within the area bounded by the “high” and “low” curves. Multiplication by the duration factor, D, has the effect of moving the point to the left. As we have stated we believe that the intensity factor (I) alone rather than the product of the duration factor and the intensity factor, is more representative of the effect of pollution on property values. However, as already mentioned, the pollution inventory results are only available in terms of the average DI index for each of the 241 minor drainage basins.

To check the sensitivity of the benefit calculation to changes in the shape of the curve, we also calculated benefits using the dotted straight line relationship between property value and DI changes shown in Figure 12. The results obtained using the curve were about 19 percent higher than those obtained using the straight line. This moderate difference in benefits calculated on the basis of such large differences in the assumed shape of the relationship between property value and DI changes implies that the national benefit estimate is relatively insensitive to the exact shape of the curve.

BENEFIT CALCULATION

We performed the national pollution abatement calculation in three separate parts and then summed the parts to derive the total benefit. The three separate parts are the following:

1) Metropolitan benefit – This is the expected increase in the value of existing residential property and parks in all metropolitan areas of more than one million people, plus thirteen other large metropolitan areas with known water pollution.

2) Town benefit – This is the estimated benefit to property values in all towns of more than one thousand people outside of the metropolitan areas.

3) Rural land benefit – This is the estimated total increase in rural waterfront land values.

In the metropolitan and town estimates we considered the benefit of pollution abatement that will be realized as increases in the market value of existing residential and park property. Increases in value which might be attributed to land occupied by industry or transportation were ignored because although in some instances the value of the land could increase, the benefit would not be immediately realized by the public.

A factor to account for the capital value which taxes add to real property values was included in the benefit calculation. In effect, an average property tax of 2 percent [7] capitalized at ten percent per annum was added to the market value of all properties. This effectively raises the value of all properties by 22 percent. Property value estimates were also inflated wherever necessary to Fall, 1972 dollar values, using the Consumer Price Index [8].

METROPOLITAN AREAS

Our case study results indicate that potential water pollution abatement benefits measured as increases in property values can be expressed as a percent of the value of existing residences and land within 4000 feet of polluted water. The percent increase or benefit depends on the distance of the property from the water and the duration and intensity of the water pollution. To calculate the benefit within metropolitan areas we measured the area of all densely developed residential property and park lands which would be affected by pollution abatement. Each area was classified according to its distance from the water and the duration and intensity of the water pollution. National averages for the value per unit area of densely developed residential areas and the average value of vacant land can be used to convert area measurements to dollar values.

Given the property values, distribution of property with respect to distance from the polluted water body, the intensity of the pollution, and the curve of Figure 13, the expected benefit of pollution abatement can be estimated. The benefit is the sum of all the individual property benefits computed as a percentage of their original value.

We began the estimation of the metropolitan benefit by using U.S. Geological Survey 7½-minute series topographic maps to locate and measure the area of all waterfront parks and densely developed residential areas located within 4000 feet of a water body with a pollution duration-intensity factor of greater than .2. The 7½-minute series of maps has a scale of 2000 feet per inch and provides such detail that land use patterns are clearly discernible. Streets, railroad lines, factories, storage tanks, and in many cases individual houses, are included on these maps.

The amount of dense residential area in each of six categories (depending on distance from a polluted water body) was measured using the appropriate maps for each metropolitan area, and keyed to the appropriate DI factor. The length and depth (up to 4000 feet) of all parks directly adjacent to polluted water bodies were also measured and keyed to appropriate pollution levels. The height of the river bank adjacent to the property was noted if it was over 100 feet, as was the number of train tracks between the property and the water body if there were more than one and less than four sets of tracks. Property obstructed from the water by industry, commercial buildings, more than three train tracks, a major highway, or a river bank of over 500 feet in height was not measured since it was felt that these factors would reduce the positive effect of water pollution abatement to negligible levels. The area occupied by dense residential development within four thousand feet of polluted water measured by the preceding criteria in all metropolitan areas of over a million persons is summarized by distance category in Table 10. The numbers are rather small because land along river banks and harbors is dominated by industry and transportation, since industry originally developed in close proximity to water channels providing transportation, power, and waste disposal.

It was arbitrarily assumed that pollution abatement impacts on property values are decreased 50 percent by two lines of railroad track at the water's edge and 90 percent by three to compensate for the obstructing effects which these rights-of-way undoubtedly produce. It was further assumed for computational simplicity that the effects of water quality improvements would decrease in a linear fashion as the height of the river bank increases from 100 to 500 feet (that is, no benefit would be felt above 500 feet). We estimated that neglecting residential property obstructed from the water by more than one line of tracks or a bank over 100 feet high would decrease the total benefit estimate by less than 6 percent.

Given our case study results, it seems reasonable to assert that the benefits of improved water quality to unobstructed residential and park property generally decreases proportionally as the reciprocal of the distance to the water, and that the effects are negligible beyond four thousand feet. The functional relation between percent increase in property value and distance to the water which provided the best results at the Willamette River site was used in the metropolitan benefit calculation. This is appropriate because most of the residential areas affected by water pollution are adjacent to rivers. The function which is graphed in Figure 13, has the following form:

$$\text{Percent Increase} = \frac{(1200 - .3 \times \text{Distance to water})}{\text{Distance to water} + 1000} \times \text{Percent increase at 100 feet}$$

The value per unit area of densely developed residential property was estimated using the 19,000-dollar U.S. 1970 median value of a single-family residence [6], and 7770 square feet as the average house lot size corrected to include area occupied by streets. We used data from our study sites to estimate the average lot size.

A value of 100,000 dollars per acre was used for park land in metropolitan areas. This figure is based on the value of vacant land in San Francisco, Berkeley, and San Diego, California; Charleston, West Virginia; Portland, Oregon; and Seattle, Washington. Increases in land value were the only pollution abatement benefits assigned to parks in the national benefit estimate, although many other park benefits may result from cleaner water, such as, increased enjoyment by park visitors. In this sense we underestimate the park benefit for the sake of computational ease.

Table 10. AREA OF RESIDENTIAL PROPERTY AND WATERFRONT PARKS AFFECTED BY WATER POLLUTION IN METROPOLITAN AREAS OF MORE THAN ONE MILLION POPULATION

Type of Property	Distance from Polluted Water Body (in feet)	Area (in Square Miles)
Dense Residential	0 to 500	6. 23
	500 to 1000	8.04
	1000 to 1500	5.65
	1500 to 2000	6.67
	2000 to 3000	7.70
	3000 to 4000	6.02
	0 to 4000	40.31
Waterfront Park	0 to 4000	133.61

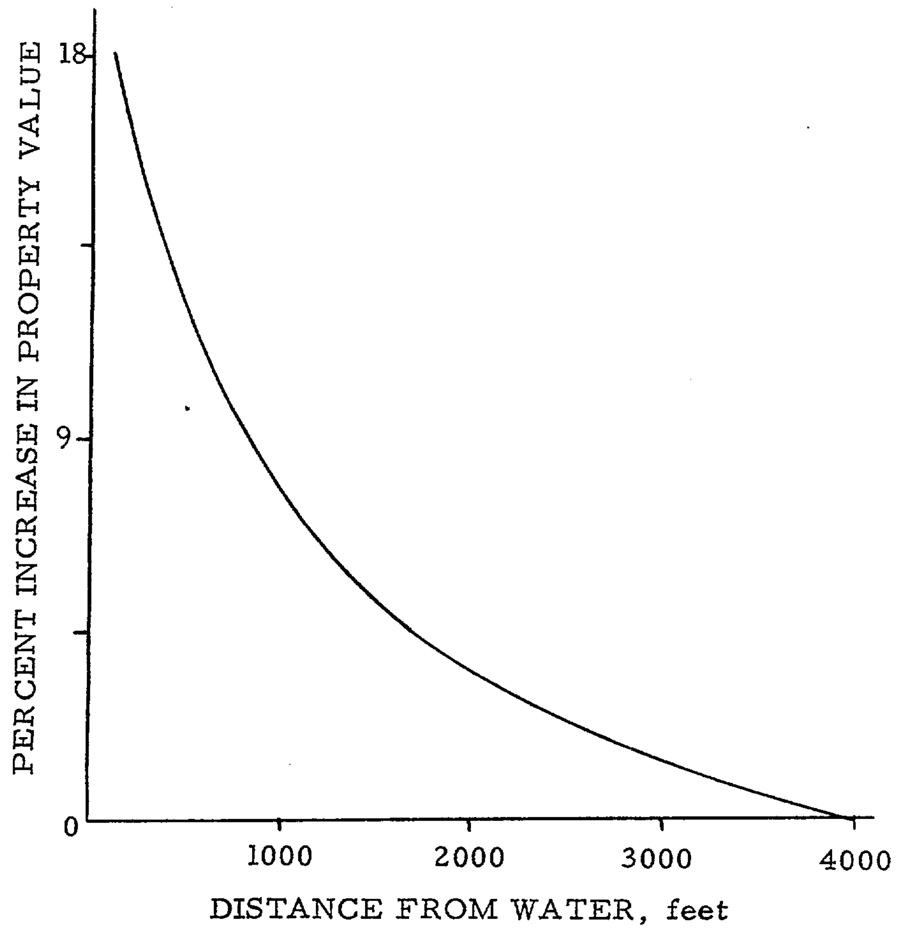

Figure 13

RELATIONSHIP BETWEEN BENEFIT (IN PERCENTAGE TERMS) AND WATER DISTANCE USED FOR MEDIUM NATIONAL BENEFIT CALCULATION

The land value increase is the most straightforward portion of the benefit to define and measure. Only parks or portions of parks with direct unobstructed water contact were measured. We designed and wrote a computer program to calculate the expected total increase in property values from measured areas, distances, and pollution levels. Assuming a maximum 18 percent increase in property value (corresponding to a DI change from 1 to 0) 100 feet from the water body and the functional relationship between percent increase and distance to the water plotted in Figure 13, the estimated potential benefit for all metropolitan areas of over a million population plus 13 other large metropolitan areas with known water pollution, was a 307 million dollar increase in existing residential property values, and a 208 million dollar increase in the value of land now occupied by waterfront parks.

TOWNS

There are many towns with populations from 100 to 1,000,000 located adjacent to large polluted water bodies. To simplify the calculation of the benefit to these towns, we assumed a relationship between the population of a town and the maximum potential benefit achievable from pollution abatement. The maximum potential benefit is defined here as the total increase possible in the sum of community property values if all adjacent water was initially polluted to a level equal to a DI factor of one, and then improved to a level equal to a DI of zero.

Town of over 1000 population affected by pollution were identified from the large scale U.S. Geological Survey maps upon which we had marked polluted water and then classified according to their pollution level and orientation to the water. Towns were ignored if their developed area was not in direct contact with the water as shown on the maps. Thus, towns merely located near a polluted water body are not included in this estimate. We inferred that if a town was built near but not in direct contact with a river or lake, there was a reason for avoiding the water, such as flood hazard or swamps, and that these obstacles would tend to render the impact of pollution abatement on property values negligible.

We developed two functions relating population and maximum potential benefit: one for towns adjacent to water (single-bank towns) and another for towns straddling rivers (double-bank towns). To estimate the forms of the functions, a random sample of 30 of each type of town was drawn from those affected by pollution and the method used in the metropolitan area calculation was used to measure the maximum potential benefits to each of the 60 towns as accurately as possible. Then, using a least-squares numerical technique we selected a linear function to approximate the relation between maximum potential benefit and population. The two functions are graphed in Figure 14 for the case of a 10 percent increase in value of 100 feet from the water.

Quadratic functions were also tested for fit to sample data, but the linear function proved to be the most reasonable. It should be noted that we neglected towns of less than 1000 population. Although many such towns exist, their development tends to be very scattered and it was impossible for us to determine their location relationship to the water on the 1:250,000-scale maps. The properties affected by pollution abatement near

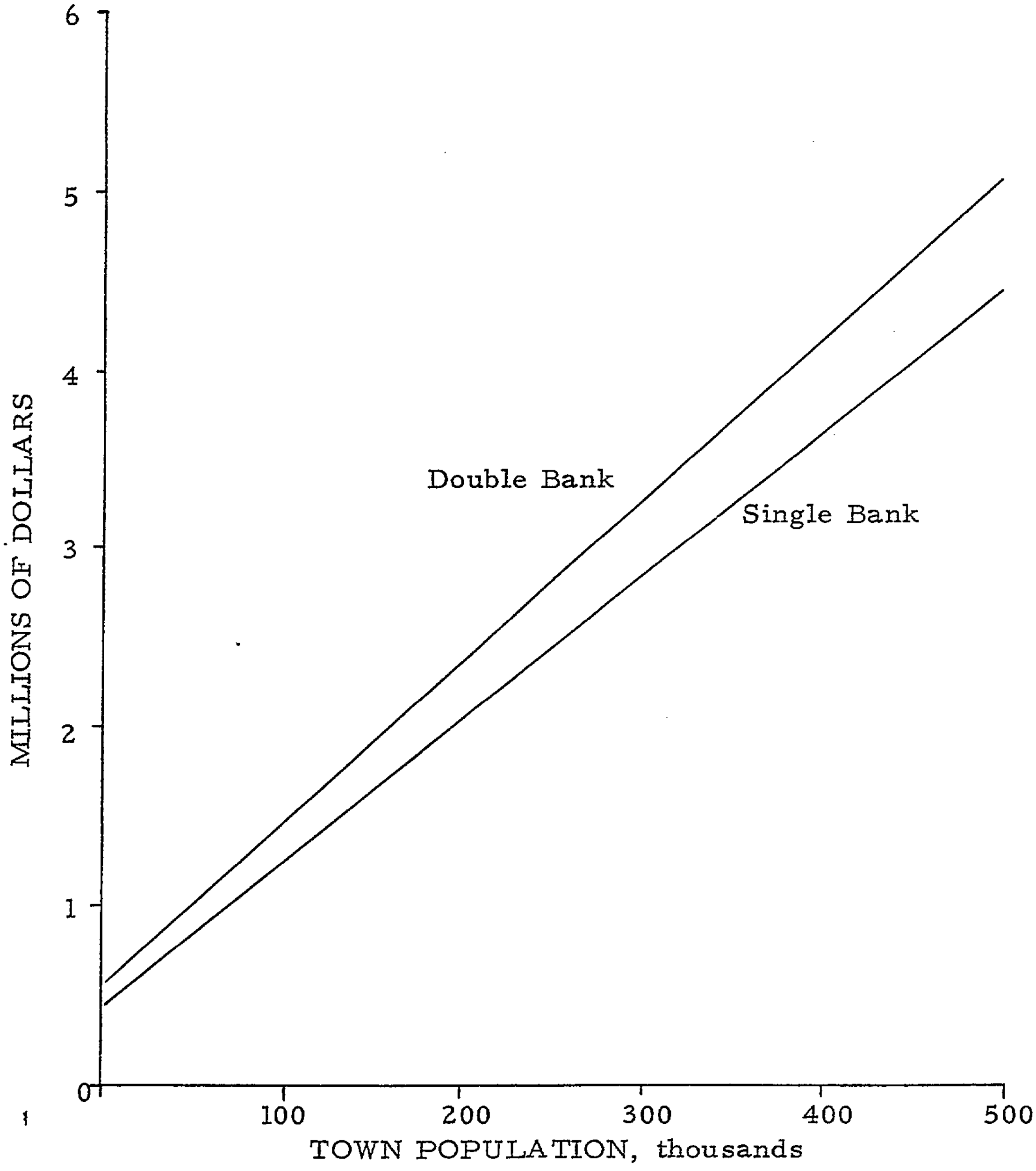

Figure 14

RELATION BETWEEN TOWN POPULATION AND
MAXIMUM POLLUTION ABATEMENT BENEFIT

these towns were included in the rural benefit measurement.

The pollution abatement benefit for each town of over 1000 population was computed by multiplying the appropriate maximum potential benefit, as determined from the functional relation between population and maximum water quality impact. times the percent of maximum benefit expected, as determined from the average minor basin pollution duration-intensity index and the curve of Figure 12. The national town benefit is the sum of the individual town benefits for 853 towns with an average population of 24,864. The medium estimate of the town benefit is summarized by major water system in Table 11.

RURAL AREAS

The values of rural land adjacent to water will also be increased by pollution abatement. This will be particularly true where there is a strong demand for rural home and recreation sites, and where the number of sites adjacent to unpolluted water is limited. We calculated the potential benefit of pollution abatement along each polluted rural river reach or shoreline as a percent increase in the estimated value of the waterfront land. The appropriate percent increase for each river bank is determined by the duration-intensity of the pollution. The national benefit was computed as the simple sum of the benefits for all of the pollution zones.

Using a percentage change regression model, we estimated that rural waterfront land near Portland, Oregon increased 65 percent as a result of pollution abatement on the Willamette River. This is a rather special case, in that the Portland metropolitan area is growing rapidly and the demand for all land in the Willamette Valley is increasing. In addition, the land has good access, most is suitable for building, and the river has considerable recreation and aesthetic value.

Because of these special circumstances in the Willamette Valley, the 65 percent increase 'n waterfront land there probably represents the maximum benefit which can be realized ›y rural land through water pollution abatement. It would be more reasonable to expect smaller property value increase in other regions of the country where the special rcumstances of the Willamette situation do not pertain. Therefore, we reasoned that ral waterfront land in these other regions, which is suitable for building and located on badly polluted lake or river with water access and low flood hazard, might show a ximum value increase of between 10 and 65 percent as the result of pollution tement. The 65 percent maximum increase of this range is equivalent to the amette River results, while the low maximum increase of 10 percent is our own most ervative estimate of the increase in the value of rural waterfront land attainable from umatic improvement in water quality.

of rural waterfront land adjacent to polluted water were measured on the U.S. gical Survey 1:250,000 topographic maps. We recorded mileages, pollution levels, ıe county and state of location. Waterfront land was classified in the following five ies: preferred river bank, shoreline, marshy, mountainous, and highway or railroad. ont land which appeared to be suitable for building (that is, accessible, dry, and

Table 11. EXPECTED BENEFIT IN TOWNS OUTSIDE LARGE METROPOLITAN AREAS (MEDIUM ESTIMATE)

Major Water System	Number of Towns	Average Population (thousands)	Average DI	Benefit Estimate (millions$)
North Atlantic	187	24.1	.7	192.0
Middle Atlantic	104	22.5	.6	100.9
South Atlantic	87	37.2	.6	100.3
Tennessee	10	30.7	.6	12.1
Ohio	201	17.0	.5	157.0
Lake Erie	33	21.4	.8	27. 3
Upper Mississippi	85	23.0	.7	78. 3
Superior-Michigan-Huron	105	19.2	.6	89.6
Missouri	11	36.1	.4	7.7
Lower Mississippi	10	135.7	.4	13.5
Colorado	---	---	---	---
Texas-Rio Grande	13	51.5	.6	13.3
Columbia-North Pacific	5	40. 8	.4	4.5
California	2	37.8	.4	1.6
Great Basin	---	---	---	---
Total	853	24. 9		798.1

not too steep) was classified as preferred river bank or shoreline. The value of this land was assumed to be 2.6 times the average value of all farm land in the county where it was located. The factor 2.6 is a national average ratio of the value of land adjacent to water to the value of land without water access [9]. The average value of all farm land by county is recorded in the 1969 Census of Agriculture [5]. By using the average value of local land, we are in effect adjusting the benefit calculation for regional differences in the demand for land.

Marshy and swampy areas are generally marked as such on the one to 250,000-scale topographic maps. Land in this classification was arbitrarily assumed to be worth only half the value of preferred land in the same county. Mountainous areas are clearly distinguishable on the topographic maps, and this land was also arbitrarily valued at half the value of preferred land because of its inaccessibility and the scarcity of building sites close to the water. Ignoring swampy or mountainous miles completely would have decreased our benefit estimates less than one percent. Many of the overland transportation routes in the U.S. follow closely along riverbanks and shorelines. About one third of all polluted waterfront miles were traversed by highways or railroad tracks or both. Highways and railways can either raise land values above the local average by providing increased access, or depress land values below the local average to the extent that they constitute a nuisance. Where highways or railroads are immediately adjacent to the water, the land has virtually no recreation potential. It was assumed here that the average net effects of highways or railroads was to depress land values 20 percent below the values of "preferred land." No economic land value studies were found which either support or reject this assumption. It was based on our own observations and intuition. However, the benefit estimates are relatively insensitive to the assumed 20 percent. The total national benefit would decrease by only about 2.5 percent if the highway and railroad miles were neglected completely. The total polluted miles measured in each category are summarized by major river basin in Table 12, and the estimated value of rural property affected by water pollution is summarized in Table 13.

In rural areas, pollution abatement was assumed to affect only the value of waterfront property, defined as that land from 120 feet distant to the water's edge. This definition seems reasonable since the depth of an average city lot is about 100 feet and a typical waterfront lot might be about 20 feet longer. According to this definition, there are 14.6 acres of waterfront land in a mile of shoreline.

The curve of Figure 12 was used to relate the pollution duration-intensity factor (DI) to the maximum percentage increase in land value due to pollution abatement. Maximum percentage increases of 10, 30, and 65 percent were used to calculate the low, medium and high national rural land benefits. The maximum percentage increases express the average waterfront land value increase which could be expected if the water quality was to improve from extremely bad (a DI factor of one) to extremely good (a DI factor of zero). Based on our urban and rural case study results, a ten percent increase is a very conservative estimate, while a 65 percent increase seems optimistic.

Table 12. MILES OF POLLUTED RURAL WATERFRONT MEASURED FOR EACH MAJOR BASIN

Major Water System	Swamp or Marsh	Mountain-ous	Highway or Railroad	Preferred River Front	Preferred Shoreline	Total
North Atlantic	10	0	2745	926	558	4239
Middle Atlantic	105	116	1240	526	0	1987
South Atlantic	1760	44	921	2853	231	5809
Tennessee	14	67	285	795	75	1236
Ohio	34	808	4469	5705	84	11100
Lake Erie	10	14	283	732	37	1063
Upper Mississippi	356	0	1216	2412	25	4023
Superior-Michigan-Huron	8	9	473	1194	287	1961
Missouri	13	87	568	1944	5	2540
Lower Mississippi	496	18	986	2858	362	4790
Colorado	0	89	155	363	50	586
Texas-Rio Grande	871	104	430	2696	141	4228
Columbia-North Pacific	6	44	585	324	0	1013
California	20	0	243	78	9	380
Great Basin	0	0	99	73	96	288
Total	3704	1400	14700	23,480	1960	45,244

Table 13. ESTIMATED VALUE OF RURAL LAND AFFECTED BY WATER POLLUTION (IN MILLIONS OF DOLLARS)

Major Water System	Swamp or Marsh	Mountain-ous	Highway or Railroad	Preferred River Front	Preferred Shoreline	Total
North Atlantic	.02	.00	25.84	15.32	5.48	46.66
Middle Atlantic	.38	.52	6.92	5.38	.00	13.20
South Atlantic	6.38	.16	6.28	21.46	2.03	36.31
Tennessee	.06	.19	2.16	7.63	.59	10.63
Ohio	.08	1.74	22.77	52.27	.63	77.49
Lake Erie	.07	.00	2.98	9.27	.59	12.91
Upper Mississippi	.97	.06	8.17	17.48	.78	27.46
Superior-Michigan-Huron	.02	.00	5.23	12.17	1.35	18.77
Missouri	.01	.02	3.19	14.10	. 00	17.32
Lower Mississippi	1.67	.17	7. 24	16.18	2.35	27.61
Colorado	.00	.05	1.66	3.72	.59	6.02
Texas-Rio Grande	3.18	.24	2.97	15.87	1.73	23.99
Columbia-North Pacific	.00	.16	2.30	1.44	.00	3.90
California	.02	.08	1.42	.61	.10	2. 23
Great Basin	.05	. 00	.44	.41	1.17	2.07
Total	12.91	3.39	99.57	193.31	17.39	326.57

COMPLETENESS OF MEASUREMENT INVENTORY

To the best of our judgment, our measurements have accounted for about 80 percent of the property affected by water pollution. This 80 percent completeness is the product of conservative assumptions, the procedures described above, and our intuitive “feel” for the inclusiveness of our measurement inventory, based on our experience with property value impact assessment and water pollution data. Our medium estimate of the national benefit is inflated to account for this assumption that we have accounted for 80 percent of all properties affected by water pollution.

We have adjusted the low and high benefit calculations to demonstrate the sensitivity of the benefit estimate to the extremes of variation in the degree of completeness assumed. The range of the variation reflects our degree of confidence in our measurement procedure. The low estimate assumes we have accounted for 100 percent of all property affected by water pollution, while the high estimate assumes a 60 percent completeness. (The high benefit estimate was inflated accordingly). We are confident that the actual completeness of our measurement inventory lies somewhere in the range of 60 to 100 percent.

The accuracy of our affected property measurements was limited by our ability to locate polluted water and to determine land use patterns from U.S. Geological Survey topographic maps. We know, for example, from the difference between the mileage of polluted waterfront we measured and the total mileage considered to be polluted in the original PDI Survey, that we did not plot every polluted water body with a DI index of .2 or greater. However, those polluted waters we overlooked would tend to be on small tributary streams in remote areas away from population and industrial centers, where pollutants are less concentrated and abatement benefits measured as property value increases would consequently be small.

In metropolitan areas the accuracy of our estimate is more dependent on locating all affected property. And some omissions were inevitable. Where residential properties are sparce, or where the residential development has occurred since the last update of the U.S. Geological Survey Maps in the 1960’s, some properties would be overlooked. Similar omissions of new waterfront parks or parks not labelled as such on the maps would also occur. In general, however, the unobstructed dense residential and park property within 4000 feet of polluted water in metropolitan areas has been carefully inventoried on very detailed maps. The total area actually measured is perhaps smaller than expected, because within most metropolitan areas a large share of waterfront land is occupied by factories, warehouses, highways, and railroads. We deliberately did not attribute any benefit to lands devoted to these activities.

We have systematically attempted to measure the towns and rural areas most likely to be affected by water pollution abatement within each minor drainage basin which has an average DI factor greater than .2. Our own judgment was necessary to locate some of these polluted water bodies on topographic maps, but we feel we have considered nearly all which are located in towns of populations greater than 1000 and those which have the greatest effect on rural land values.

LOW, MEDIUM, AND HIGH ESTIMATE RESULTS

Three estimates (a low, a medium, and a high) were calculated for the potential national increase in residential and recreational property value which can be expected to result from water pollution abatement.

The medium estimate gives the most likely value of the national benefit, based on the findings of this report. It is also based on the best estimates available for the magnitude and extent of the effects of a dramatic change in water quality on proximate residential and rural property; on our own best estimate of the relationship between the EPA's pollution duration-intensity factor (DI) and property value increases; and on our estimation of how completely we included the value changes for all property affected by polluted water.

The major assumptions for this best estimation are the following:

Assumption 1:

A change in water quality from a badly polluted condition (DI factor of one) to a condition which will sustain desirable life forms and desired and practical water uses and which is aesthetically pleasant (DI factor of zero), will increase by 18 percent the value of an unobstructed single-family residence 100 feet from the water. Furthermore, the impact of pollution abatement on property values is assumed to decrease as an inverse function of distance from the water body, approaching zero at four thousand feet. These assumptions are based on the results of our case studies on the Willamette River, Kanawha River, and San Diego Bay.

Assumption 2:

The same water quality change described under Assumption 1 will increase the value of rural waterfront land by thirty percent.

Assumption 3:

It is assumed that our measurements included 80 percent of all properties affected by water pollution.

The results of the computation for the medium estimate are summarized by major water system in Table 14. The total national benefit according to this estimate is 1.35 billion dollars. About 59 percent of this benefit will accrue to towns, 31 percent to metropolitan areas (with population greater than one million), and only 10 percent to rural river bank and lakeshore.

The "low" estimate reflects the national benefit obtainable under very conservative assumptions. In our opinion, there is a .85 probability that the national benefit is actually greater than this estimate. This is a subjective probability assessment which reflects our own judgment. It is based on confidence levels derived from our case studies, our belief in the validity of our assumptions and approximations, and the sensitivity of our final estimates to variations in uncertain variables.

The assumptions incorporated in the low estimate are the following:

Table 14. EXPECTED RESIDENTIAL AND RECREATIONAL PROPERTY VALUE INCREASE (MEDIUM ESTIMATE) OBTAINABLE BY WATER POLLUTION ABATEMENT (MILLIONS OF $)

Major Water System	Metro Areas	Towns	Rural	Total
North Atlantic	131.6	192.0	20.7	344.3
Middle Atlantic	22.5	100.9	5.5	128.9
South Atlantic	40.8	100.3	17.7	158.8
Tennessee	---	12.1	5.5	17.6
Ohio	29.0	157.0	24.8	210.8
Lake Erie	15.0	27.3	4.4	46.7
Upper Mississippi	26.8	78.4	10.9	116.1
Superior-Michigan-Huron	79.5	89.5	7.1	176.1
Missouri	18.4	7.7	5.6	31.7
Lower Mississippi	5.9	13.5	9.3	28.7
Colorado	---	---	2.2	2.2
Texas-Rio Grande	50.0	13.3	10.4	73.7
Columbia-North Pacific	---	4.5	1.4	5.9
California	2.6	1.6	.7	4.9
Great Basin	---	---	1.1	1.1
Total	422.1	798.1	127.3	1347.5

Assumption 1:

A water quality change from a DI factor of one to zero will increase the value of a single-family residence 100 feet from the water by 10 percent.

Assumption 2:

Rural waterfront land values will be increased a maximum of 10 percent by pollution abatement.

Assumption 3:

We have accounted for all properties affected by water pollution.

The "high" estimate is the benefit calculated for very optimistic assumptions. We feel that the probability is about .85 that the actual national benefit is less than this high estimate. The assumptions incorporated in the high estimate are the following:

Assumption 1:

The maximum increase in residential property values 100 feet from the water is 30 percent.

Assumption 2:

Rural waterfront land will realize a maximum 65 percent increase from pollution abatement.

Assumption 3:

We have accounted for only 60 percent of all properties affected by water pollution.

The results of the three estimates are summarized in Table 15. The total capital value of the low estimate is approximately .6 billion dollars, the medium is about 1.35 billion, and the high is nearly 3.1. The comparative magnitude of these values is perhaps clearer when we note that the median estimate is equivalent to about one-half of one percent of the taxable value of all non-commercial and non-industrial property in the nation. The annualized value of the medium estimate is 76 million dollars per year when calculated by standard accounting procedures, using a discount rate of six percent and an infinite time horizon.

We cannot overemphasize the precise extent and limitations of these benefit estimates. The estimates reflect the expected increase in existing residential and recreational property values if pollution levels in all water bodies in the contiguous United States are reduced to conditions which are not inhibiting to desirable life forms or desired practical water uses, and which are aesthetically agreeable. This benefit would be realized whether or not cities and states took any positive action to acquire waterfront land or to provide parks or make efforts to change land use patterns. Concerted water clean-up efforts together with active programs to develop residences, commerce, and recreation facilities near safe water bodies would substantially increase the benefits calculated in this study, particularly in metropolitan areas. In San Diego Bay, for example, hotels, restaurants, marinas, and other recreation facilities are being built on man-made islands where such developments would be nonsensical if the bay remained polluted.

Table 15. NATIONAL BENEFIT OF POLLUTION ABATEMENT ON PROPERTY VALUES

(Millions of Dollars)

Estimate	Metropolitan Areas		Towns	Rural	Total	Total Annualized Value using 6% discount rate
	Residential	Parks				
Low	112	75	355	34	576	33
Medium (most likely)	252	170	798	127	1347	76
High	560	379	1774	368	3081	175

Some additional comments will place this benefit estimate in theoretical perspective. First, we have estimated the value of a complete water clean-up rather than the marginal benefit of incremental improvements in pollution levels. This seemed the logical way to produce meaningful results, given the limited number of case studies and limited availability of information about the characteristics, intensity, and distribution of water pollution. Another point is that due to supply and demand interactions, the market price of most economic goods such as property near clean water, will decrease as more of it becomes available. We have not made any adjustments in our estimates to compensate for this effect. However, the change in price should theoretically be small. and therefore so should the effect on our benefit estimate. The fraction of total housing and land which is affected by water pollution is small in any given region, while the total housing market offers a large number of substitutes for an amenity such as proximity to clean water (for example, a view or additional space). The large number of close substitute commodities implies that the price of any single commodity (in this case, property near clean water) will be relatively insensitive to small changes in its supply.

The actual total of tangible and intangible benefits which could be realized from water pollution abatement would be much greater than what we have estimated in this study. Our principal concern was to estimate only the benefit reflected in increased property values, and that increase only for existing residential and park property. Future changes in land use to high-yield uses rendered possible by water pollution control represent a potentially very large benefit which remains uncounted in our estimate. Perhaps the greatest benefit of unpolluted water will be the satisfaction derived by all people, property owners and non-property owners alike, from their assurance that the nation's water bodies are a continuing healthful resource and fit habitat for all forms of life.

Section VII

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Section VIII
References

1. Federal Water Pollution Control Administration, *Water Quality Criteria*, Report of the National Technical Advisory Committee to the Secretary of the Interior, Washington, D.C., U.S. Government Printing Office, 1968.

2. Litton, R. Burton, Jr., et al., "An Aesthetic Overview of the Role of Water in the Landscape," Springfield, Virginia, National Technical Information Service, 1971.

3. O'Connor, Michael F., "The Application of Multi-Attribute Scaling Procedures to the Development of Indices of Value," Technical Report, Engineering Psychology Laboratory, Ann Arbor, University of Michigan, 1972.

4. Rothenburg, Jerome, *Economic Evaluation of Urban Renewal,* Washington, D.C., 1967.

5. U.S. Department of Commerce, Bureau of the Census, "Area Reports," *1969 Census of Agriculture,* Vol. I, Washington, D.C., U.S. Government Printing Office.

6. U.S. Department of Commerce, Bureau of the Census, "Metropolitan Housing Characteristics," *1970 Census of Housing, Washington,* D.C., U.S. Government Printing Office, 1971.

7. U.S. Department of Commerce, Bureau of the Census, "Taxable Property Values," *1967 Census of Governments*, Vol. II, Washington, D.C., U.S. Government Printing Office, 1968.

8. U.S. Department of Commerce, Bureau of Labor Statistics, *Handbook of Labor Statistics,* Washington, D.C., U.S. Government Printing Office, 1971.

9. U.S. Department of the Interior, Bureau of Outdoor Recreation, *Recreation Land Price Escalation*, Washington, D.C., U.S. Government Printing Office, 1967.

10. U.S. Department of the Interior, Office of Water Resources Research, *Methodology to Evaluate Socio-Economic Benefits of Urban Water Resources,* Washington, D.C., U.S. Government Printing Office, 1971.

11. U.S. Environmental Protection Agency, *Economics of Clean Water,* Vol. II, Washington, D.C., U.S. Government Printing Office, 1972.

12. Wolman, M. Gordon, "The Nation's Rivers," *Science,* Vol. 174, 1971, pp. 905-918.

Appendix References

1. Gleeson, George W., "The Return of a River: the Willamette River, Oregon," Corvallis, Oregon State University, June 1972.

2. State of Oregon, 'Department of Environmental Quality, "Water Quality Control in Oregon," Portland, Oregon, December 1970.

3. Stone, Ralph, and Company, Inc., Engineers, "Estuarine-Oriented Community Planning for San Diego Bay," prepared for Federal Water Pollution Control Administration, June 30, 1969.

Section IX

Appendices

APPENDIX A

CORONADO

(SAN DIEGO BAY)

Coronado, located just across from San Diego, is bordered on the northwest by the Naval Air Station, on the southwest by the Pacific Ocean, and on the east by the San Diego Bay. The residences enjoy relatively flat topography and close proximity to water oriented activities.

WATER QUALITY CHANGES

In 1960, San Diego voters passed a bond issue for construction of the San Diego Metropolitan Sewerage System. Construction of the system began in 1961, the system became operational in 1963, and by the end of 1964, all shore-based sewage discharges to San Diego Bay were ended. The project led to a significant improvement in water quality (see Table A-1).

By 1960, almost two-thirds of the entire bay had dissolved oxygen (DO) levels below 4 ppm while in central bay areas DO levels dropped below 1 ppm [3]. Between 1960 and 1963, (before the sewerage system began operations) biological oxygen demand (BOD) increased at a rate of about five percent annually, which probably caused DO levels to deteriorate proportionally. Many areas of the bay developed anaerobic conditions producing offensive odors and an unsightly appearance. By 1965 however, as a result of the sewerage project, DO levels had increased to over 5ppm in most of the bay (including off-shore Coronado), allowing many desirable fish species to return.

Fecal coliform density, measured by a most probable number (MPN) index, is generally accepted as a reasonably valid statistical analysis of the bacteriological quality of a particular water sample [3]. The level of MPN is used to indicate the proportion of human and animal waste pollution. The California State Board of Public Health requires that at a public beach the MPN shall not exceed 1000 per 100 ml.

Prior to operation of the new sewerage system, coliform densities adjacent to Coronado exceeded the State's public health standard, and the beaches were quarantined. Since the cessation of domestic sewerage outfall into the bay there have been no public beach restrictions on water contact activities.

Before 1964, floating solids of sewage origin collected in "rafts" on the bay surface and along the shoreline, producing both public health hazards and aesthetic deterioration. Now, Coronado and other community residences enjoy a clean and pleasing bay [3].

Table A-1: SAN DIEGO BAY WATER QUALITY: BEFORE AND AFTER CLEANUP [3]

Characteristic	1960 Before Cleanup	1965 After Cleanup
Chemical		
Dissolved Oxygen Concentrations (by percent of Bay surface)		
more than 4 mg/l	26	100
more than 5 mg/l	13	97
more than 6 mg/l	4	81
more than 7 mg/l	0	6
Coliform Bacteria		
F. Coli Concentrations (by percent of Bay surface)	(1963)	
MPN always less than 1000/100 ml	—	9
MPN usually less than 1000/100 ml	49	91
MPN often in excess of 1000/100 ml	18	—
MPN usually in excess of 1000/100	33	—
Physical		
Clarity (Secchi Disc readings, depth ft)	less than 10	greater than average
Sludge deposits	(1951)	
Thickness (ft)	3-7	less than 1
Areal Extent (percent decrease)	—	70
Floating Debris (storm drainage)	No measurable Change	
Floating Refuse from Vessels	Extensive	Moderate
Foam of Waste Origin	Extensive	None
Perlite	Extensive	Moderate
Grease	Widespread	None
Oil Slicks (primarily from ships)	No change, but more perceptible in clean Bay.	
Plankton Growths		
Color	Yellow-Brown & Red	Light Green
Number of Major Algal Blooms	Many	One, as a result of a Dredging Project
Odors	Noxious	Normal salt water

Table A-1 (continued)

Characteristics	1960 Before Cleanup	1965 After Cleanup
Bay Water Color	Brownish	Blue-green
Fish	Loss of Desirable Species	Return of Desirable Species Including: Bonito, Black Sea Bass, Sole, Halibut, Sculpin, Sand Bass, Octopus, Bonefish, Striped Bass, Steelhead Trout, Silver Salmon, Yellowtail, Barracuda, Angle Shark

Source: San Diego Regional Water Quality Control Board.

PROPERTY VALUE CHANGES

Property values reflecting conditions before water quality improved, were calculated using 1964 assessed values. (Coronado was physically appraised in 1963). We converted the assessed values into proxies for sales prices on the basis of a calculated sales ratio of 24.1 percent. (This ratio is the average of four sales ratios for the years 1961 through 1964, for single-family residential properties in San Diego. The State Equalization Board provided the ratios to us). We then inflated each estimate using the Consumer Price Index (CPI), in order to account for inflation between 1964 and 1971.

In order to estimate the consistency (degree of deviation from the average) of assessed values to sales prices we performed our own sales ratio study. We collected data on 32 sales between 1968 and 1970. The results showed reasonable consistency:

mean of the ratio of assessed value to sales price (100%):	0.81
standard deviation:	0.102
(standard deviation / mean) x 100:	12.5%

We calculated property values reflecting conditions after water quality improved, using transaction taxes levied on 1971 sales. In Coronado, the transaction tax equals $1.10 per $1000 of the selling price of the property.

We estimated the change in market value of a particular piece of property by subtracting the 1963 estimate from the 1971 value. However, the real economic value of real estate includes not only the market price, but also the property taxes as well. In order to make annual tax payments commensurate with a present market value, we discounted the 1964 and 1971 property taxes using a 10 percent discount rate and an infinite time horizon. (1964 taxes were adjusted using the CPI to account for inflationary differences). The change in the real economic value of a single-family residence was then estimated by adding the change in market value to the change in discounted property tax payments for the respective years.

One hundred thirteen (113) observations comprised the final sample of properties used in the regression analysis. We attempted to eliminate all of those properties that had undergone major improvements or similar changes that might have hampered the reliability of results.

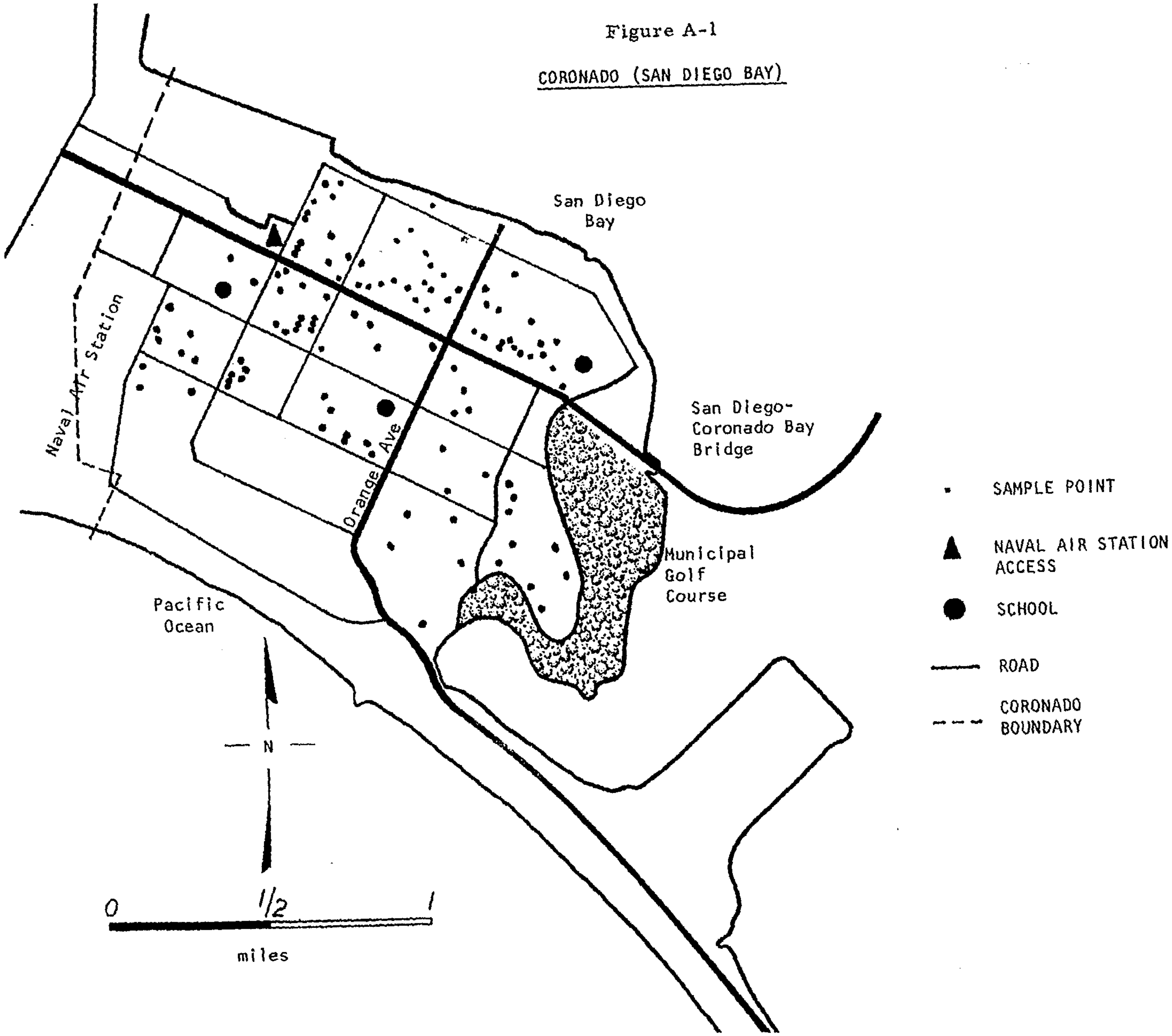
See Figure A-1 for the location of important influences within the site.

Various linear and non-linear functional forms for the water quality term were tested. The linear form proved to give the best fit for both absolute and percent value changes with distance from the bay.

Population changes, housing density changes, and racial composition changes were left out of the regressions because no major shifts in these factors were indicated by the

Figure A-1

CORONADO (SAN DIEGO BAY)



Census data, and their inclusion would not have improved the reliability of the water quality term. A concentrated area of multi-family government housing was razed within census tract 110 in 1969. The effects of this change should be accounted for by the "distance to bridge access" variable in the regression equation.

Census Data

	Total Population		Non-White Population		No. Single-Family Housing Units	
Tract	**1960**	**1970**	**1960**	**1970**	**1960**	**1970**
107	1500	1471	18	35	355	346
108	2700	2621	35	122	710	739
109	2036	1960	15	41	703	786
110	4307	1908	703	102	570	773
111	3714	3603	39	110	1214	1480

APPENDIX B

CLACKAMAS COUNTY: RESIDENTIAL

(WILLAMETTE RIVER)

Located just north of Oregon City along the east side of the Willamette River, the Clackamas County site provides approximately three miles of homogeneous residential real estate. The terrain is relatively flat except for the river bank which is steep in some places. Residences in the area enjoy easy access to the water and those living adjacent to the river enjoy a beautiful view as well.

WATER QUALITY CHANGES

A strong Water Quality Control program under the Oregon Department of Environmental Quality has brought about a significant improvement in the water quality of the Willamette River, particularly within the last ten to fifteen years.

Figures B-1 and B-2 indicate the extent to which industrial and municipal pollution has been reduced. Industrial waste discharges were reduced 86 percent, while municipal waste discharges (and their industrial components) declined eight-nine percent, overall [2]. Between 1957 and 1970, major biological oxygen demand (BOD) discharges from both industrial and municipal sources decreased from about 20 million population equivalents to about one-half million (Figure B-2). Figure B-1 shows improvement in dissolved oxygen (DO) levels for Portland Harbor during the critical summer months between 1957 and 1970. In addition, sludge deposits and slime growth have steadily declined over the years.

Figure B-3 shows the DO profile along the Willamette River for selected years [1]. Also indicated is the relative location of the two case study areas (residential and rural). Levels of DO at the residential site during the low flow period have almost doubled between 1956 and 1970. Figure B-4 shows the improvement in the fecal coliform count for the months of August and September between 1962 and 1970 [1]. Both study areas now reside well within desirable water quality standards.

PROPERTY VALUE CHANGES

We estimated property values, reflecting earlier conditions, by using 1963 assessments. (The site was physically appraised in 1962 for the 1963 tax roll). We converted assessments to sales estimates using an assessed value to sales price ratio of 24.4 percent. (The Clackamas County estimate of the average assessed value to sales price. ratio for 1963). Finally, we inflated these estimates into 1970 dollars using the Consumer Price Index (CPI).

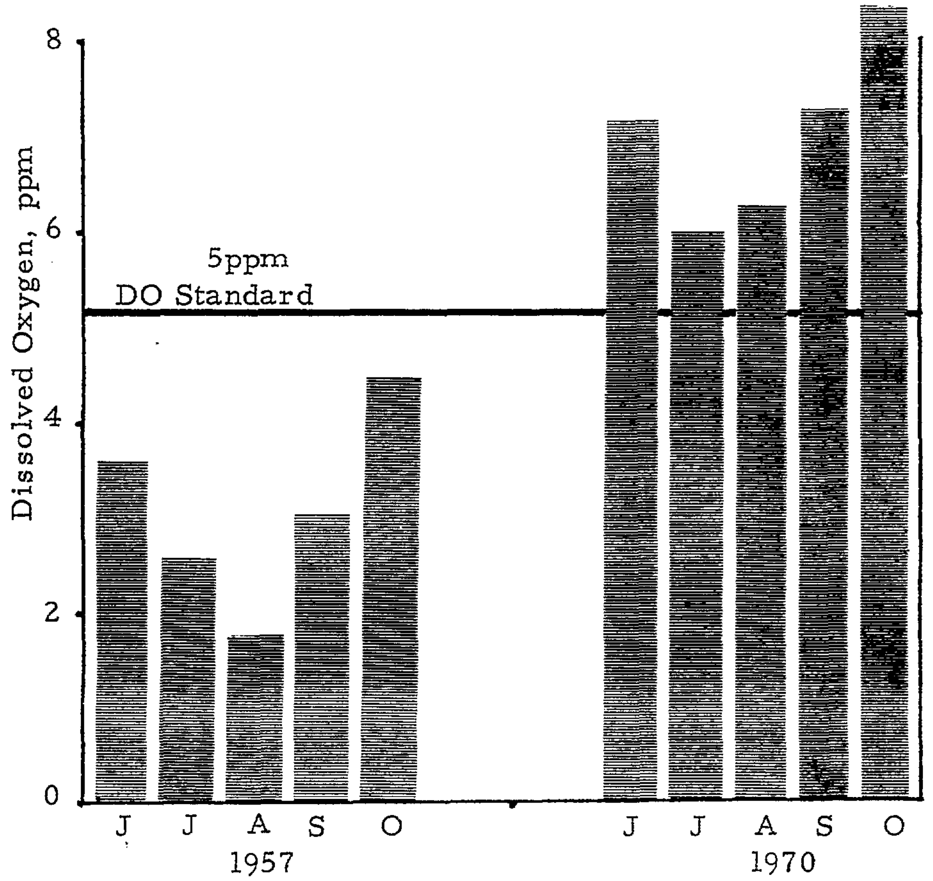


Figure B-1

Dissolved Oxygen Levels - Lower Willamette River
Low Flow Months - June-October [2]

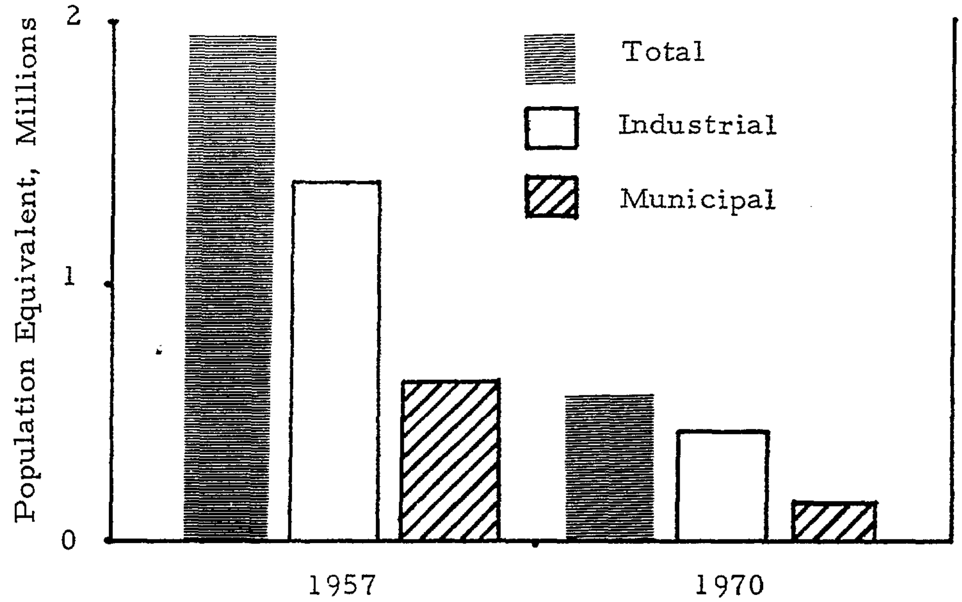


Figure B-2

Major BOD Discharges [2]

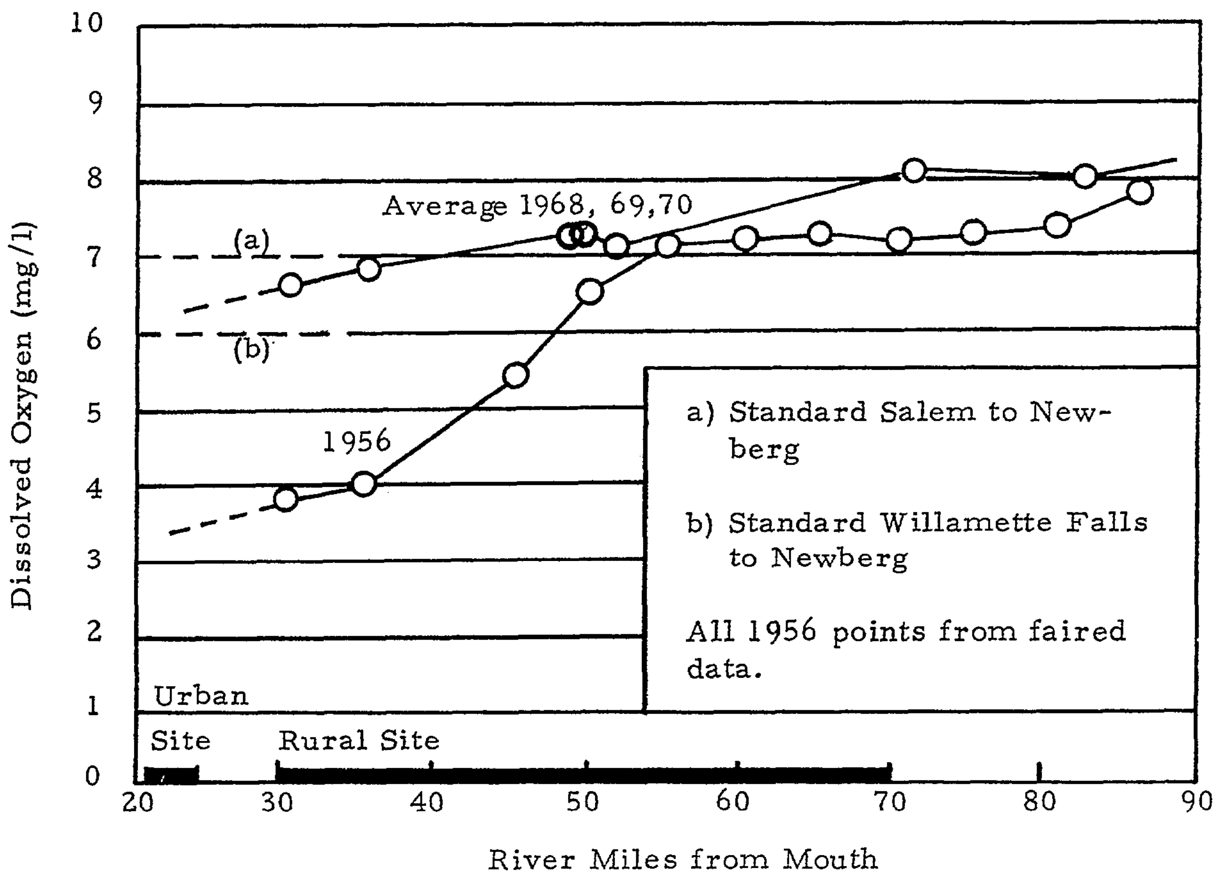


Figure B-3

Dissolved Oxygen Levels for Selected Years [1]

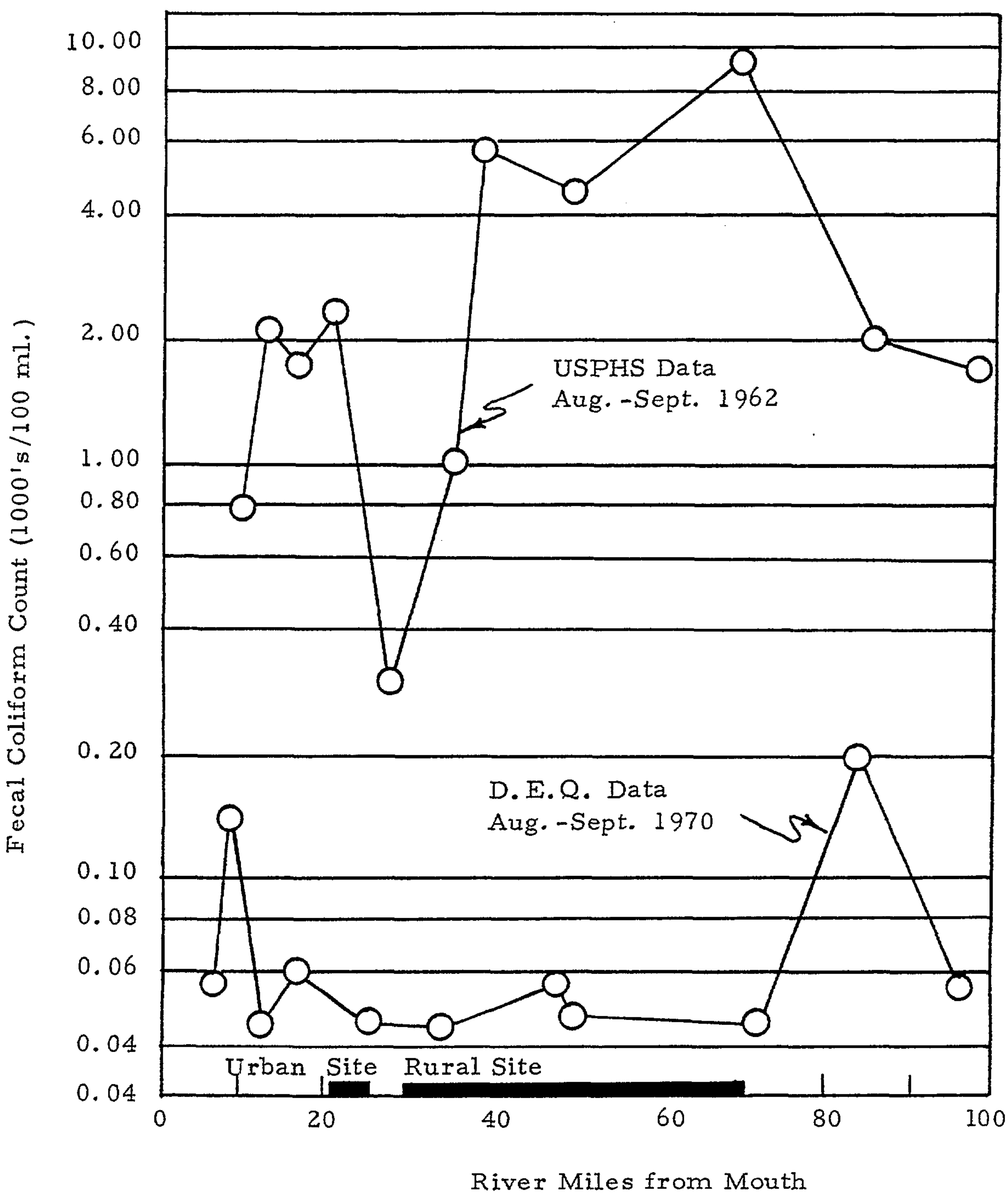


Figure B-4 Fecal Coliform for 1962 and 1970 [1]

We attempted to measure the consistency with which assessed values reflect true market values (or rather a fixed proportion of true market prices) by conducting our own sales-ratio study. We collected data on fifty-nine (59) properties that had sold during 1969 and that had been physically appraised during the previous year. The results indicated that appraisers demonstrate reasonable consistency:

mean of the ratio of sales price to assessed value (100%):	1.101
standard deviation:	0.110
(standard deviation / mean) x 100:	10.0%

Clackamas County provided actual sales price information on single-family residences that sold between 1969 and 1971 within the study area. We adjusted these values using the CPI to reflect 1970 prices.

We estimated the change in market value of each property by subtracting the 1963 adjusted assessment from the more recent sales price. The change in the real economic value of each property was then approximated by adding the change (adjusted for increases in the CPI) in discounted tax payments over the period of observation to the change in estimated market value. We used a discount rate of 10 percent and an infinite time horizon to calculate the present capital value of taxes.

See Figure B-5 for the location of important elements within the study area.

Population changes, housing density changes, and racial composition changes were not included in the regressions because no major changes which would interfere with measurement of water pollution effects were evident from the census data, and therefore their inclusion would not improve the reliability of the water term.

Census Data

	Total Population		**Non-White Population**		**No. Single-Family Housing Units**	
Tract	**1960**	**1970**	**1960**	**1970**	**1960**	**1970**
212	2282	3135	- -	- -	647	559
213	3407	4599	- -	.2	1077	1286
217	2902	4077	.1	.1	960	1024

HISTORY OF THE ANALYSIS

Ninety-eight (98) observations comprised the sample of properties used in the regression. We sought to include only those properties which had not experienced major improvements or similar changes that might have interfered with the reliability of results.

Both linear and non-linear functional forms of the water quality term were tested. The non-linear form (reciprocal of the distance to the river) appeared to give the best description of both absolute and percentage value changes.

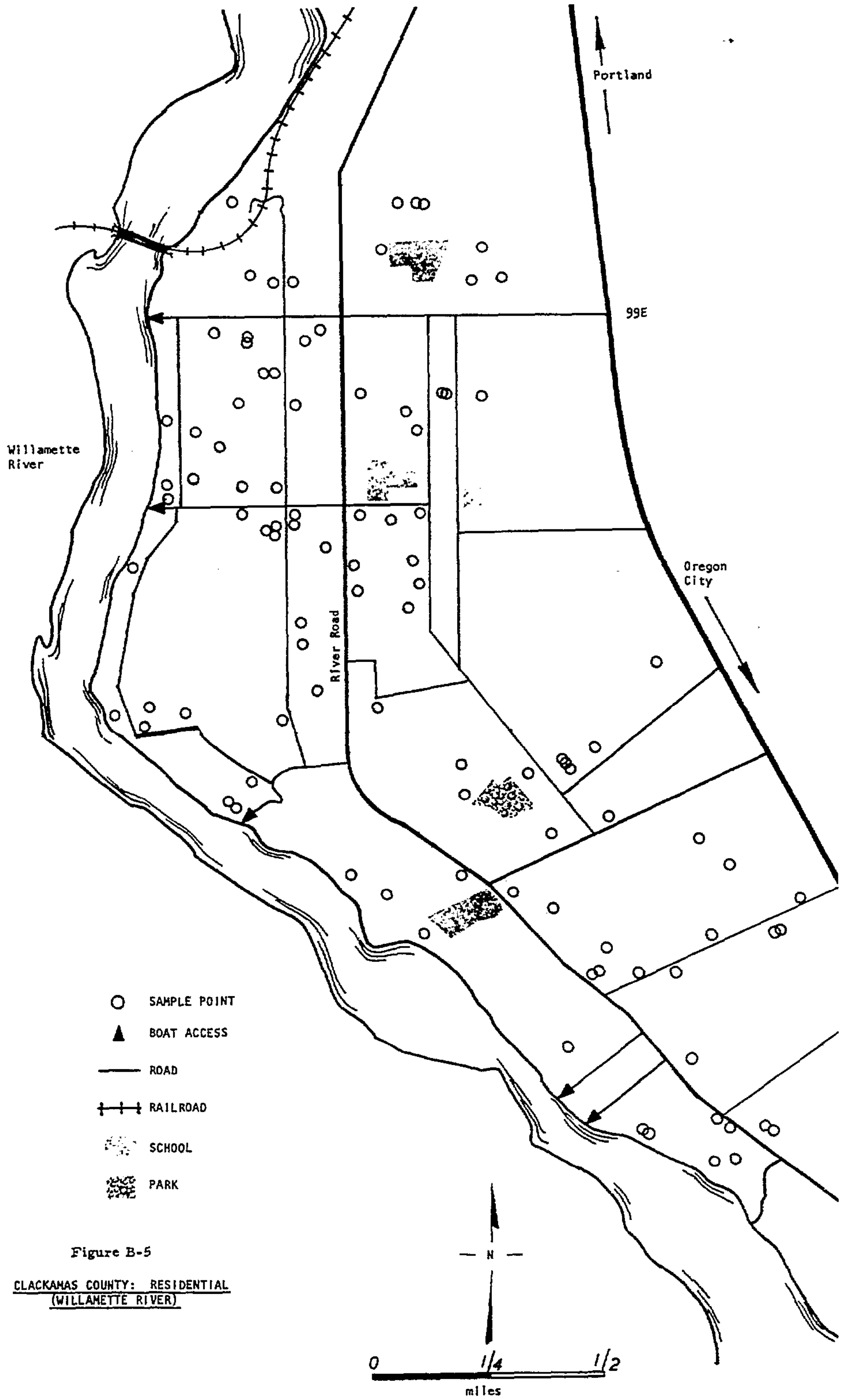


Figure B-5

CLACKAMAS COUNTY: RESIDENTIAL (WILLAMETTE RIVER)

APPENDIX C

CLACKAMAS COUNTY: RURAL LAND

(WILLAMETTE RIVER)

The rural site extends south along the Willamette River from just below Oregon City in Clackamas County to just above Wheatland Ferry Landing (near Hopewell in Yamhill County). While the study area covers almost forty miles of river, most of the properties are concentrated in the first fifteen miles south of Oregon City.

WATER QUALITY CHANGES

See Appendix B for a description of water quality changes along the Willamette River.

PROPERTY VALUE CHANGES

We used assessment data from the years around 1960 to estimate the per acre market value of each property. Clackamas and Marion Counties provided the sales ratios (assessed value to market value) for rural land, 18.1 and 23.2 percent respectively, which we used to convert the data into reliable market estimates.

We measured the consistency of rural land assessments for both counties from the range of ratios for a sample of known sales. We collected data on 28 properties in Clackamas County and 48 in Marion County. The results of the study indicated the Clackamas County assessments to be the more consistent of the two, as is evident from the following comparison:

Clackamas County:

mean of the ratio of sales price to assessed value (100%):	1.062
standard deviation:	0.122
(standard deviation / mean) x 100:	11.5%

Marion County:

mean of sales price to assessed value (100%):	1.313
standard deviation:	0.225
(standard deviation / mean) x 100:	17.1%

Clackamas, Marion, and Yamhill Counties provided actual price information on recent sales within the study area (1968-1972). We adjusted these values using the Consumer Price Index (CPI) to 1970 dollar values.

We estimated the per acre change in the market value of each property by subtracting the adjusted 1960 assessment from the 1970 sales price.

The change in the real economic value of rural land was then approximated by adding this value change to the change (adjusted for inflation) in discounted tax payments over the period of observation. We used a discount rate of ten percent and an infinite time horizon to calculate the present capital value of taxes.

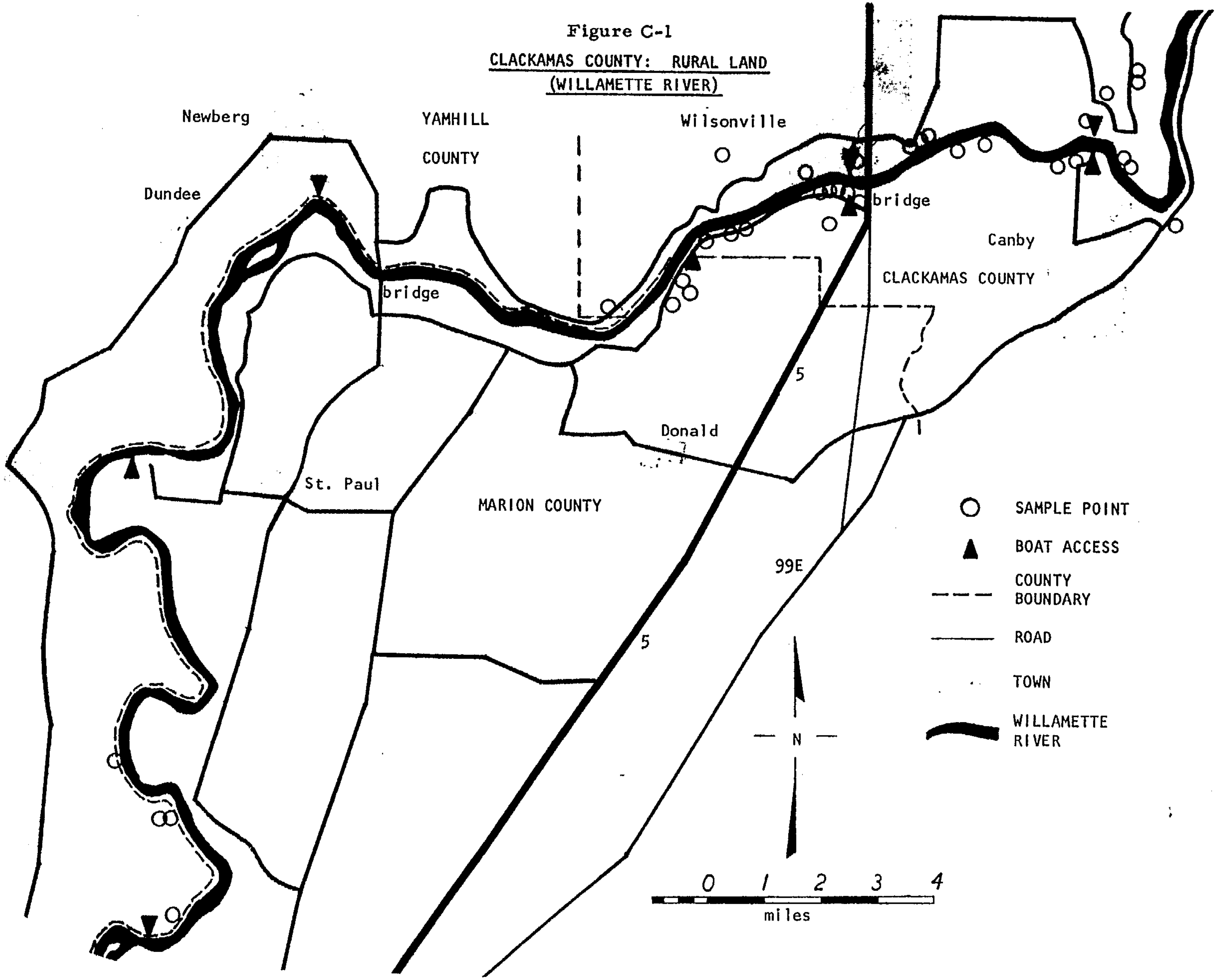
See Figure C-1 for the location of important elements within the site.

HISTORY OF THE ANALYSIS

Thirty-four (34) observations comprised the sample of properties used in the regression. There is a low correlation between land area and improvement value so we eliminated all properties with improvements in order to only capture the value changes of land itself. We tested both linear and reciprocal forms of the water quality term, and found that the reciprocal form gave the best description of property value changes as a function of distance from the Willamette River.

Figure C-1

CLACKAMAS COUNTY: RURAL LAND
(WILLAMETTE RIVER)



APPENDIX D

CHARLESTON, WEST VIRGINIA

(KANAWHA RIVER)

A section of Charleston called Kanawha City, the study area, provides almost two miles of dense residential development along the Kanawha River. The area is flat with a steep, twenty-foot river bank. Residences adjacent to the Kanawha enjoy both private river access and a scenic view.

WATER QUALITY CHANGES

Figures D-1 through D-4 report the extent to which pollution has been reduced over the study period with respect to four parameters: ammonia concentration (NH_3), hydrogen ion concentration (pH), dissolved oxygen (DO), and odor (data provided by the West Virginia Department of Natural Resources). Each parameter shows a marked improvement. According to the Department, readings were taken four times daily from the Kanawha City Bridge during the low flow period of the summer months. The graphs depicted represent average monthly conditions for the years 1960 through 1962, and for 1966 through 1968. In addition to abatement of pollutants reported above, all visual pollution was also removed by 1964.

PROPERTY VALUE CHANGES

Because of inconsistencies in assessment data prior to 1967, we used sales prices to reflect market conditions before the water quality change. We collected data on sales between 1959 and 1961, and adjusted the prices to 1970 dollar values using the Consumer Price Index (CPI).

We used 1968 assessed values to estimate market prices after the water quality of the Kanawha River had improved. The assessments were converted to proxies for market values using an estimated sales ratio of 84.8 percent (our estimate, based on a recent study; see below). These data were then inflated into 1970 dollar values using the CPI.

We measured the consistency of the county appraisers' assessments by conducting our own sales ratio study. We collected data on forty recent sales in Kanawha City, and determined that consistency was adequate for our purposes, as is shown below.

mean of the ratio of assessed value (100%) to actual sales price:	0.848
standard deviation:	0.096
(standard deviation / mean) x 100:	11.3%

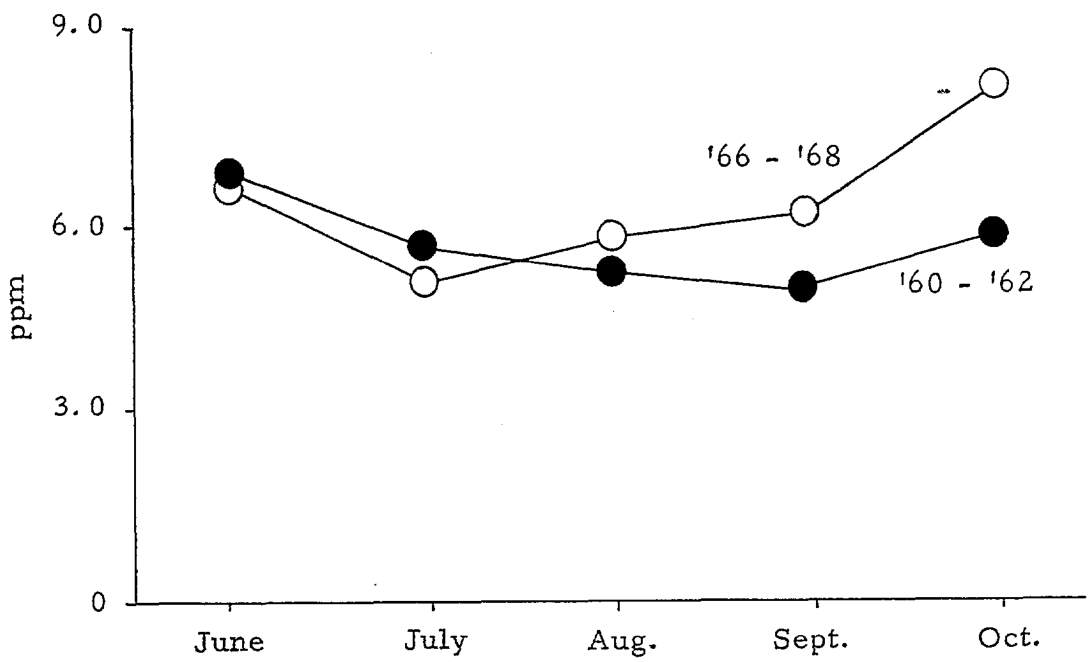


Figure D-1 Average Monthly Dissolved Oxygen Levels

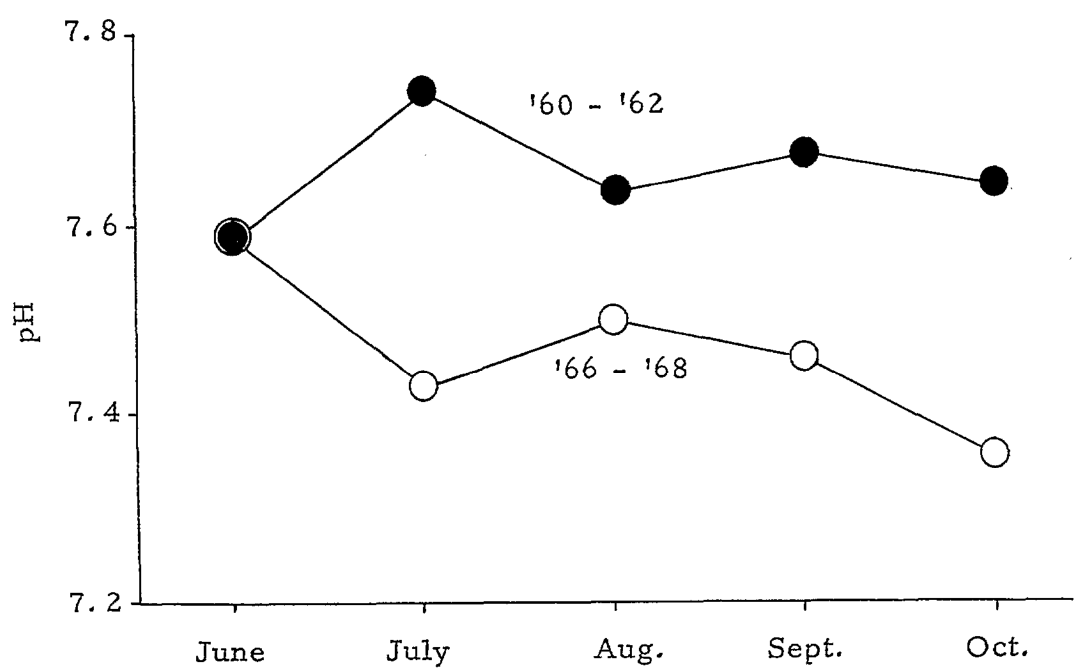


Figure D-2 Average Monthly Hydrogen Ion Concentrations

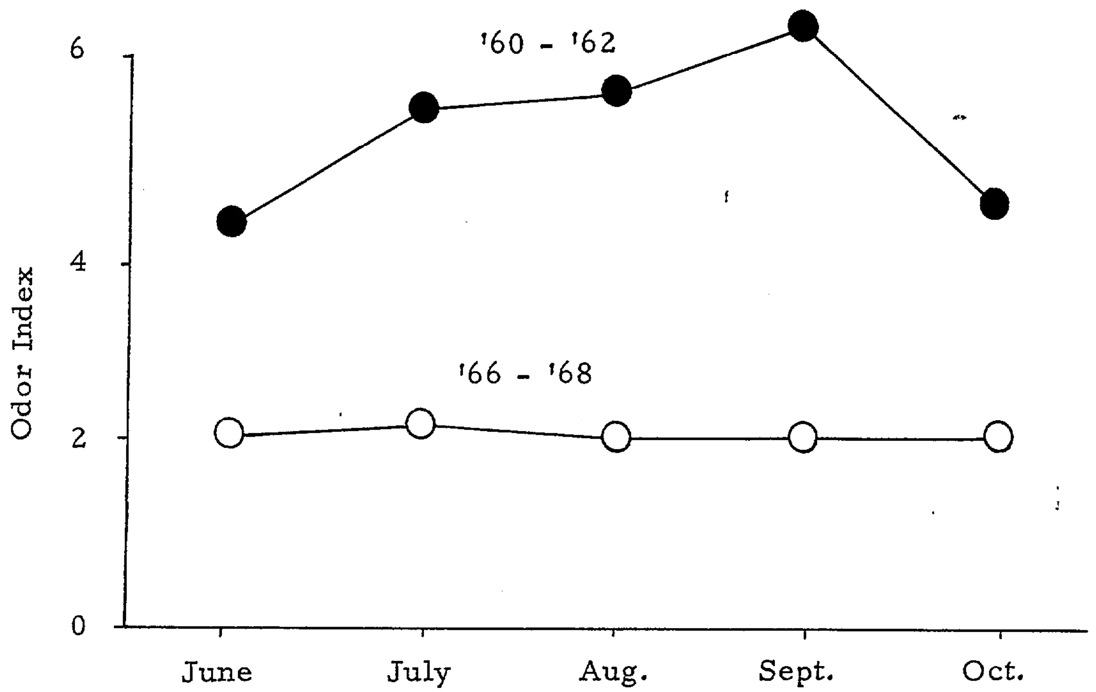


Figure D-3 Average Monthly Odor Levels

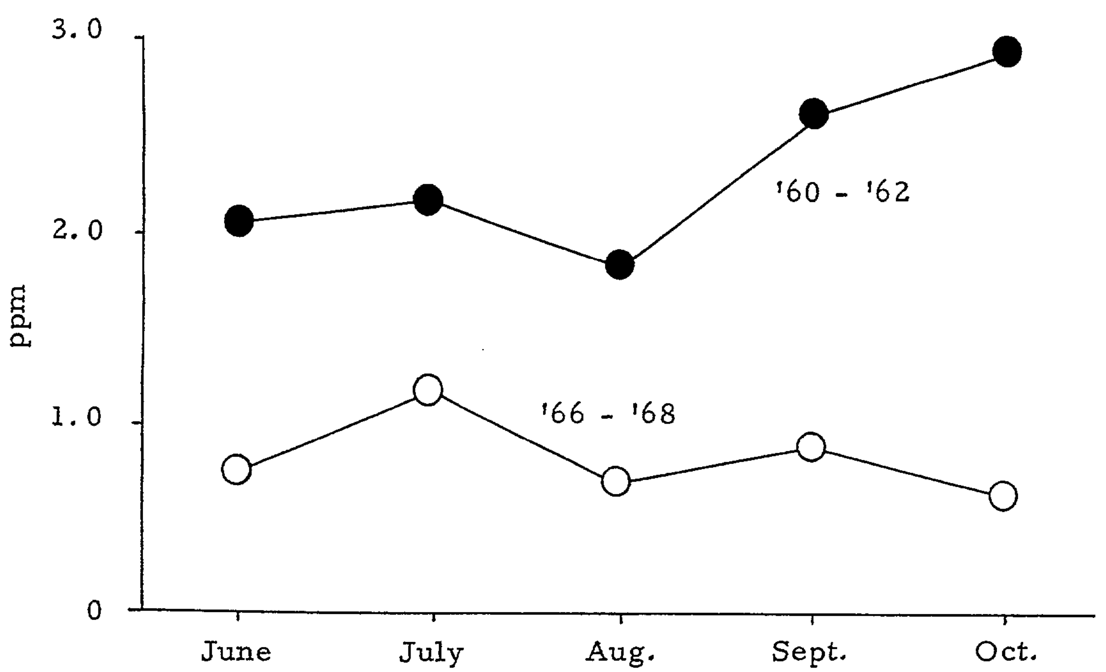


Figure D-4 Average Monthly Ammonia Concentrations

We calculated the estimated change in the market value of each property by subtracting the earlier sales price from the later market estimate. The change in the real economic value of residential property was then approximated by adding this value change to the change (adjusted for inflation) in discounted tax payments over the period of observation. As before, we used a discount rate of ten percent and an infinite time horizon to calculate the present capital value of the change in taxes.

See Figure D-5 for the location of important elements within the site.

Socio-economic factors were not included in the analysis because the census data for 1960 were found to be incomplete. It should be noted that while these factors would undoubtedly increase the explanatory power of the equation (R^2), there is no evidence that they would improve the reliability of the water quality term.

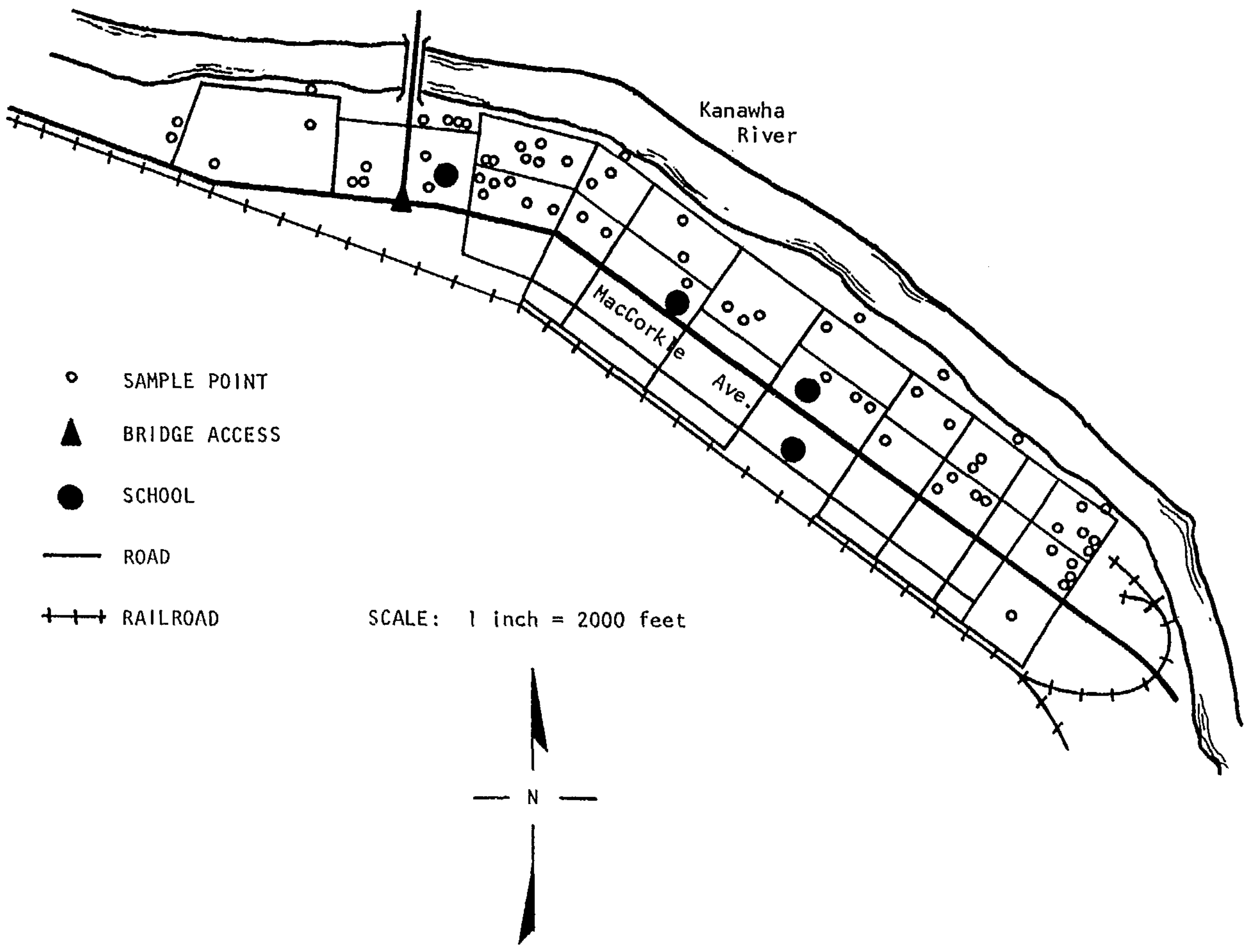
HISTORY OF THE ANALYSIS

Sixty-five (65) observations constitute the sample of properties used in the final analysis. Observation points located on the north side (river side) of MacCorkle Avenue (the commercial street) were eliminated after preliminary computations, because the effects of water quality changes apparently did not extend beyond this barrier.

We tested both linear and reciprocal functional forms of the water term. The reciprocal form as shown in Tables 6 and 7 gave the best description of value changes attributable to water quality improvement.

Figure D-5

CHARLESTON, WEST VIRGINIA
(KANAWHA RIVER)



APPENDIX E

DUNBAR, WEST VIRGINIA

(KANAWHA RIVER)

Located about four miles west of Charleston on the north side of the Kanawha River, the town of Dunbar provides more than a mile of residential real estate for study. Like Charleston, the site terrain is flat except for the steep river bank. Residences adjacent to the Kanawha enjoy both private access and a scenic view of the river.

WATER QUALITY CHANGES

Figures E-1 through E-3 are derived from data provided by the West Virginia Department of Natural Resources; they indicate the degree of improvement in water quality over the study period. While ammonia concentrations show almost no change, dissolved oxygen (DO) and odor improved moderately. As in the Kanawha City site, readings were taken four times daily from the Dunbar Bridge adjacent to the study area during the summer months. The graphs depicted represent average monthly pollution levels for the years 1960 through 1962, and for 1966 through 1968. In addition to the improvement in DO and odor, "visual pollutants" were removed by 1964.

PROPERTY VALUE CHANGES

Because of inconsistencies in the asessment data for Dunbar prior to 1967, we used sales prices to reflect market conditions around 1960. We collected data on sales between 1959 and 1961, and adjusted these to 1970 dollar values using the Consumer Price Index (CPI).

Property values from a 1968 property appraisal provided the only usable assessment data. Later years, after the water had improved more, would have been preferable but property has not been systematically reappraised since 1968. We converted the assessments into proxies for market values using an estimated sales ratio of 90.1 percent (our estimate, based on a recent study; see below). These data were then inflated into 1970 dollars using the CPI.

We measured the consistency of appraisers' assessments of residential property by doing a sales ratio study. We collected data on forty-five (45) recent sales in Dunbar. The results reported below indicate reasonable consistency:

mean of the ratio of assessed (100%) to sales price:	0.901
standard deviation:	0.130
(standard deviation / mean) x 100:	14.4%.

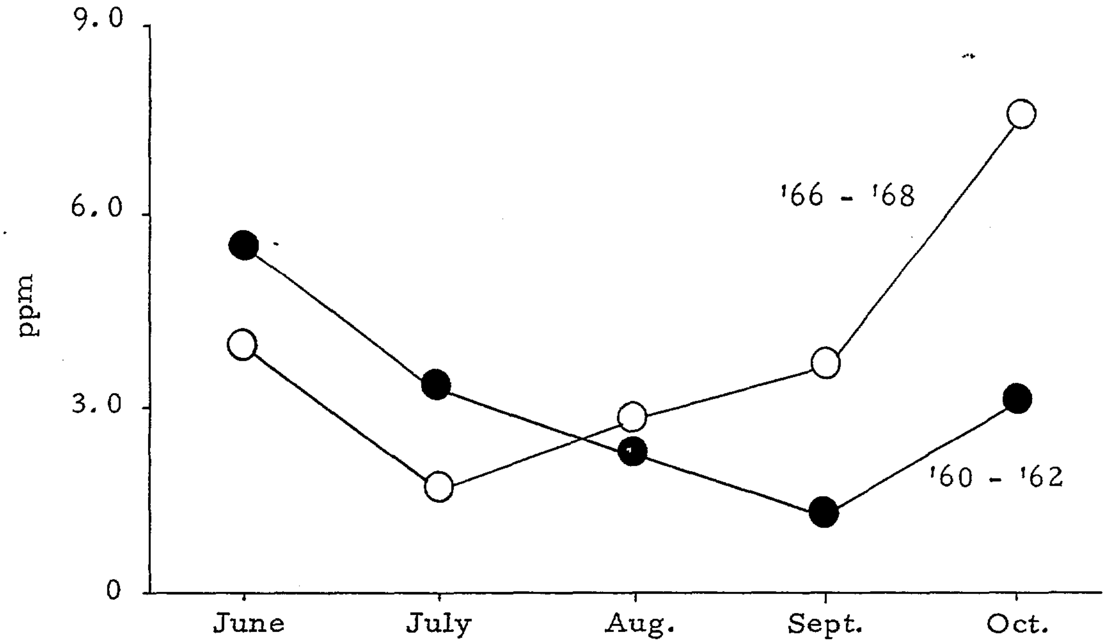


Figure E-1 Average Monthly Dissolved Oxygen Levels

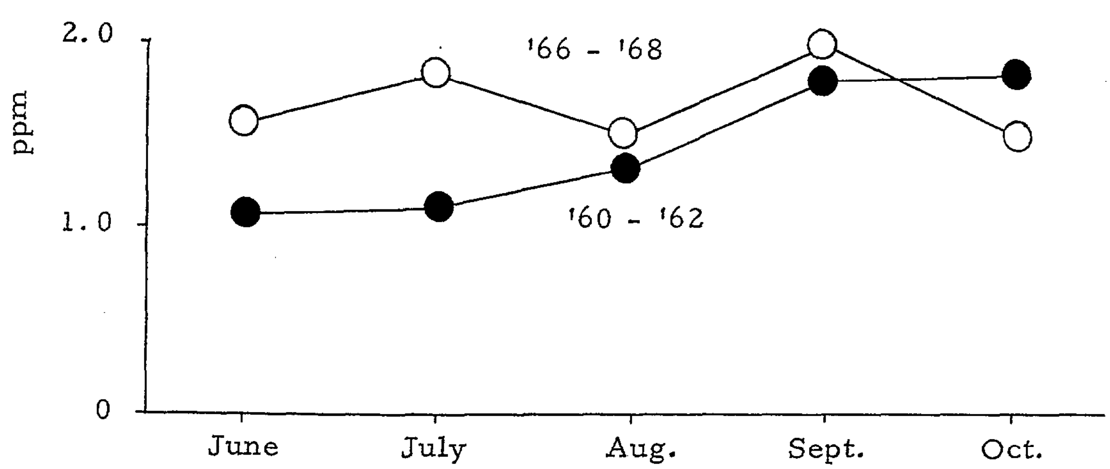


Figure E-2 Average Monthly Ammonia Concentrations

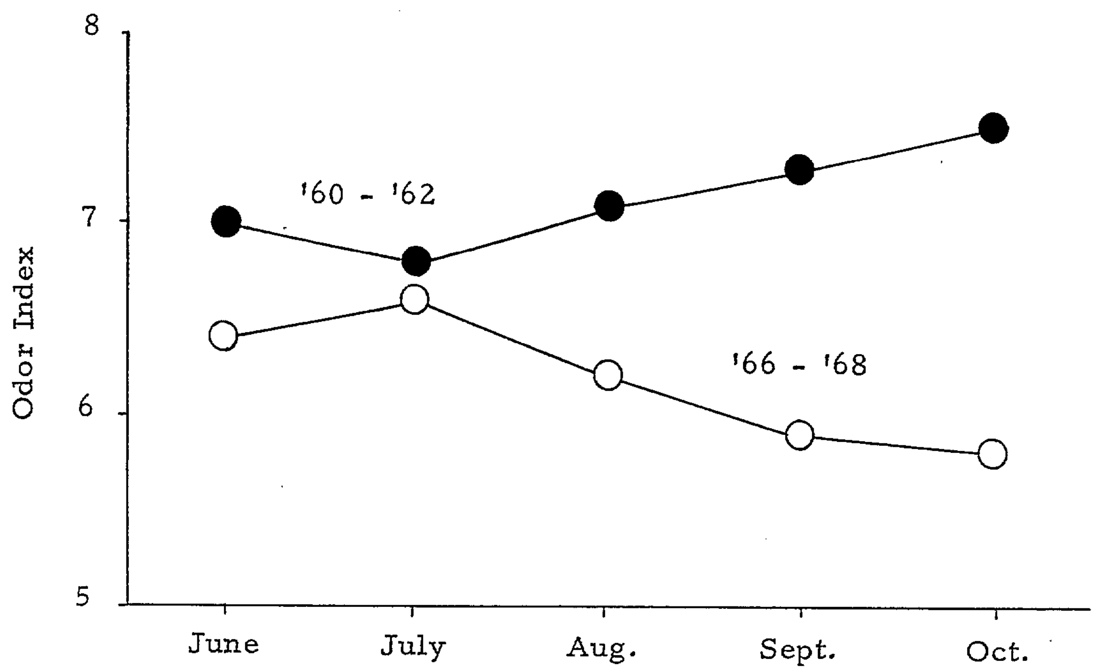


Figure E-3

Average Monthly Odor Levels

We calculated the estimated change in the market value of each property by subtracting the earlier sales price from the later market estimate. The change in the real economic value of residential property was then estimated by adding to this market value change, the change (adjusted for CPI increases) in discounted tax payments over the period of observation. As with our other sites, we assumed a discount rate of ten percent and an infinite time horizon.

See Figure E-4 for the location of important elements within the study area.

Socio-economic factors could not be included in the regression analysis because, as in Kanawha City, appropriate data for 1960 was not available. Similarly, while these influences would undoubtedly have increased the explanatory power of the equations (the R^2s), there was no evidence of changes which would influence the reliability of the water quality term.

HISTORY OF THE ANALYSIS

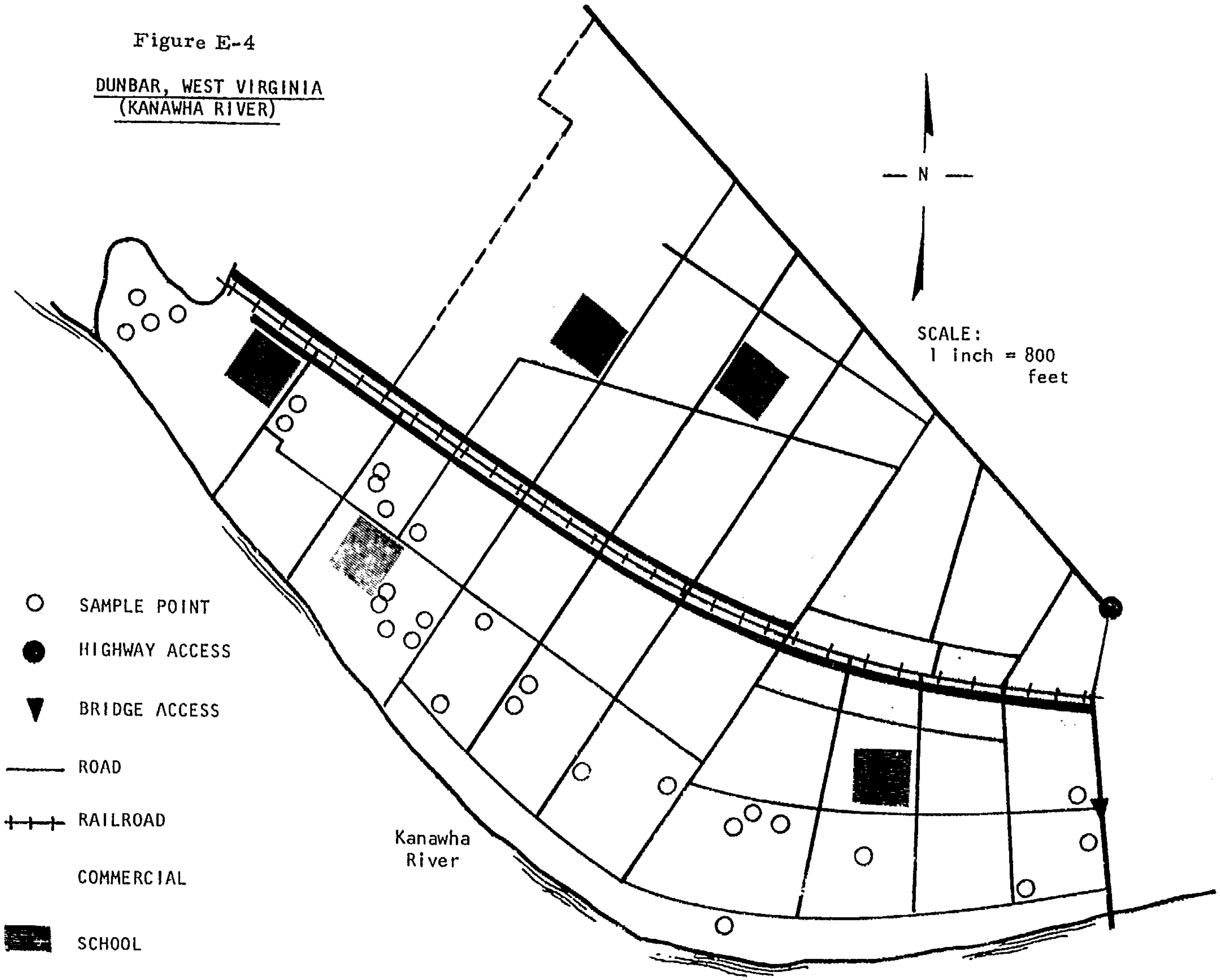
Twenty-nine (29) observations constituted the final sample of properties used in the analysis. Many observations were eliminated at Dunbar because of irregularities in property values as measured from tax records.

Observation points located on the far side of the railroad tracks were also eliminated after preliminary computations which indicated that the effects of the water quality changes did not extend beyond this barrier.

We tested both linear and reciprocal forms of the water quality term. The reciprocal form (reciprocal of the distance to the Kanawha River) appeared to give the best description of value changes, even though it too proved to be inconclusive.

Figure E-4

DUNBAR, WEST VIRGINIA
(KANAWHA RIVER)



APPENDIX F

BEAVER, PENNSYLVANIA

(OHIO RIVER)

Located about twenty miles downstream and northwest of Pittsburgh, the town of Beaver provides over a mile of homogeneous residential real estate along the Ohio River. The terrain is flat except for the river bank which is generally steep and about 60 feet high.

WATER QUALITY CHANGES

Figures F-1 through F-6, derived from data provided by the Ohio River Valley Water Sanitation Commission (ORSANCO), show the extent to which pollution has been reduced. The graphs depicted illustrate noticeable improvements in three measured parameters: dissolved oxygen (DO), specific conductivity, and hydrogen ion concentration (pH). Two continuous robot monitoring stations, one located about four miles upstream on the Beaver River near Beaver Falls and the other about ten miles upstream on the Ohio River between Beaver and Pittsburgh, performed the measurements. The graphs report the minimum or maximum monthly average readings taken at each station for the years between 1962 and 1970.

PROPERTY VALUE CHANGES

We estimated property values, reflecting earlier conditions using 1960 assessment data. (The site was physically appraised just prior to 1960). We converted assessments to sales estimates assuming an assessed value to sales ratio of 33.3 percent. (The State Equalization Board provided this ratio, on the basis of a 1962 county wide study). Finally, we inflated these estimates into 1970 dollars using the Consumer Price Index (CPI).

We measured the consistency with which assessed values reflect market values (or rather, a fixed proportion of true market prices) by conducting our own sales ratio study. We collected information on thirty-one (31) residential properties. The results reported below indicated moderate consistency.

mean of assessed value (100%) to sales price:	1.006
standard deviation:	0.205
(standard deviation / mean) x 100:	20.5%

Beaver County provided actual sales price information on single-family residences that sold between 1969 and 1971 within the study site. These values were adjusted, using the CPI, to 1970 dollars.

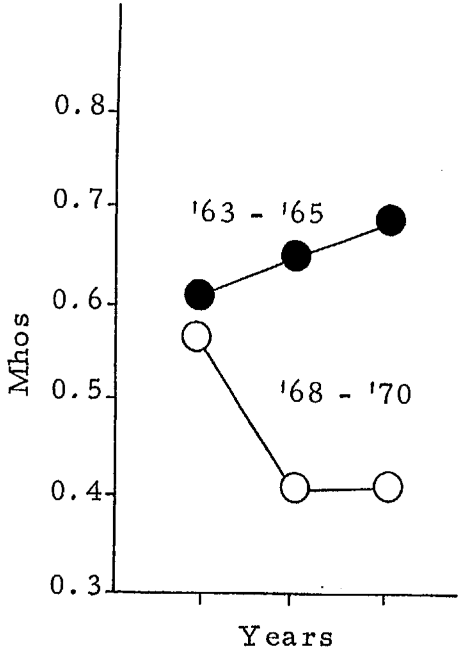


Figure F-1

Maximum Monthly Average Specific Conductivity. (Beaver Falls Station)

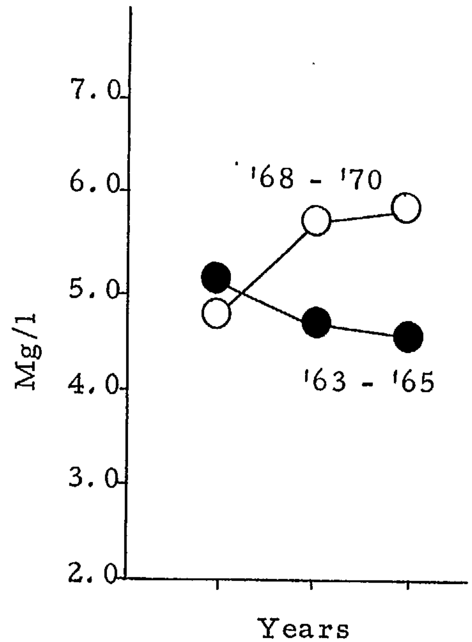


Figure F-2

Minimum Monthly Average Dissolved Oxygen. (Beaver Falls Station)

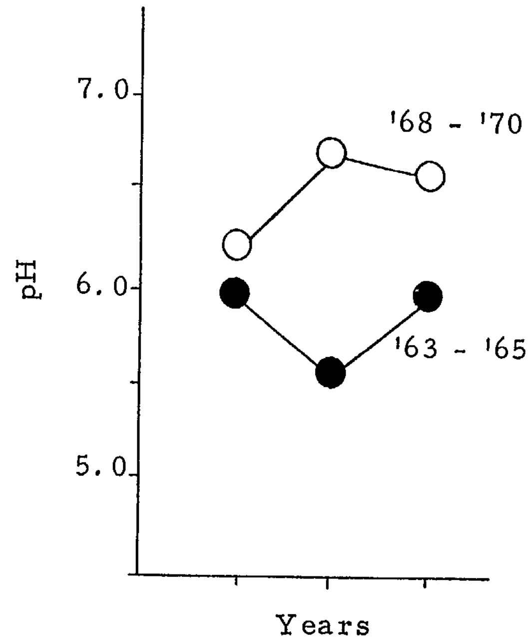


Figure F-3

Minimum Monthly Average Hydrogen Ion Concentration.
(Beaver Falls Station)

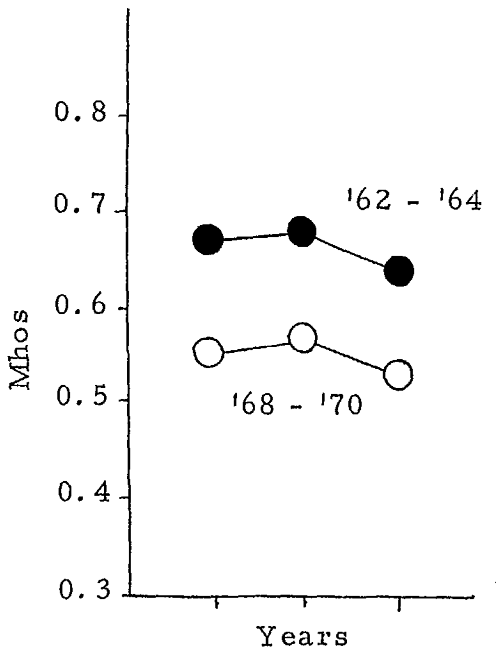


Figure F-4

Maximum Monthly Average Specific Conductivity. (South Heights Station)

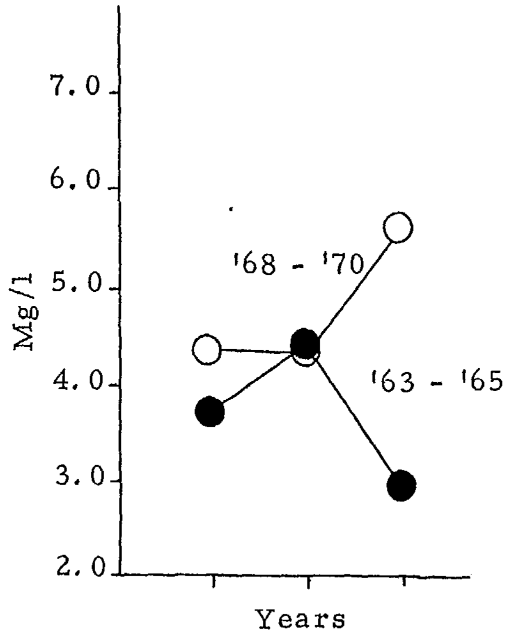


Figure F-5

Minimum Monthly Average Dissolved Oxygen. (South Heights Station)

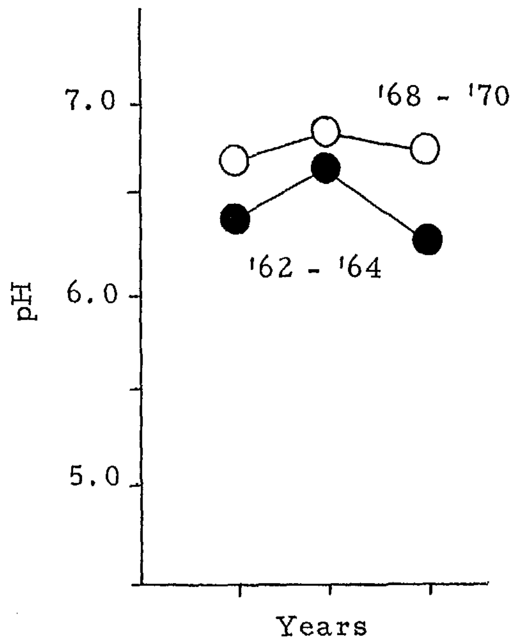


Figure F-6

Minimum Monthly Average Hydrogen Ion Concentration.
(South Heights Station)

We estimated the change in market value of each property by subtracting the 1960 value from the more recent sales price. The change in the real economic value of each property was then approximated by adding the change (adjusted for increases in the CPI) in discounted tax payments over the period of observation to the change in estimated market value. As with the rest of our study sites, we used a discount rate of ten percent and an infinite time horizon in calculating the present capital value of the change in property taxes.

See Figure F-7 for the location of important elements within the study area.

Socio-economic variables could not be included because the sample points covered only one Census Tract and there have been no significant changes in population, housing density, or racial composition within that tract.

Census Data

	Total Population		**Non-White Population**		**No. Single-Family Housing Units**	
Tract	**1960**	**1970**	**1960**	**1970**	**1960**	**1970**
6023	3303	3242	7	22	976	696
6024	2857	2858	16	17	865	780

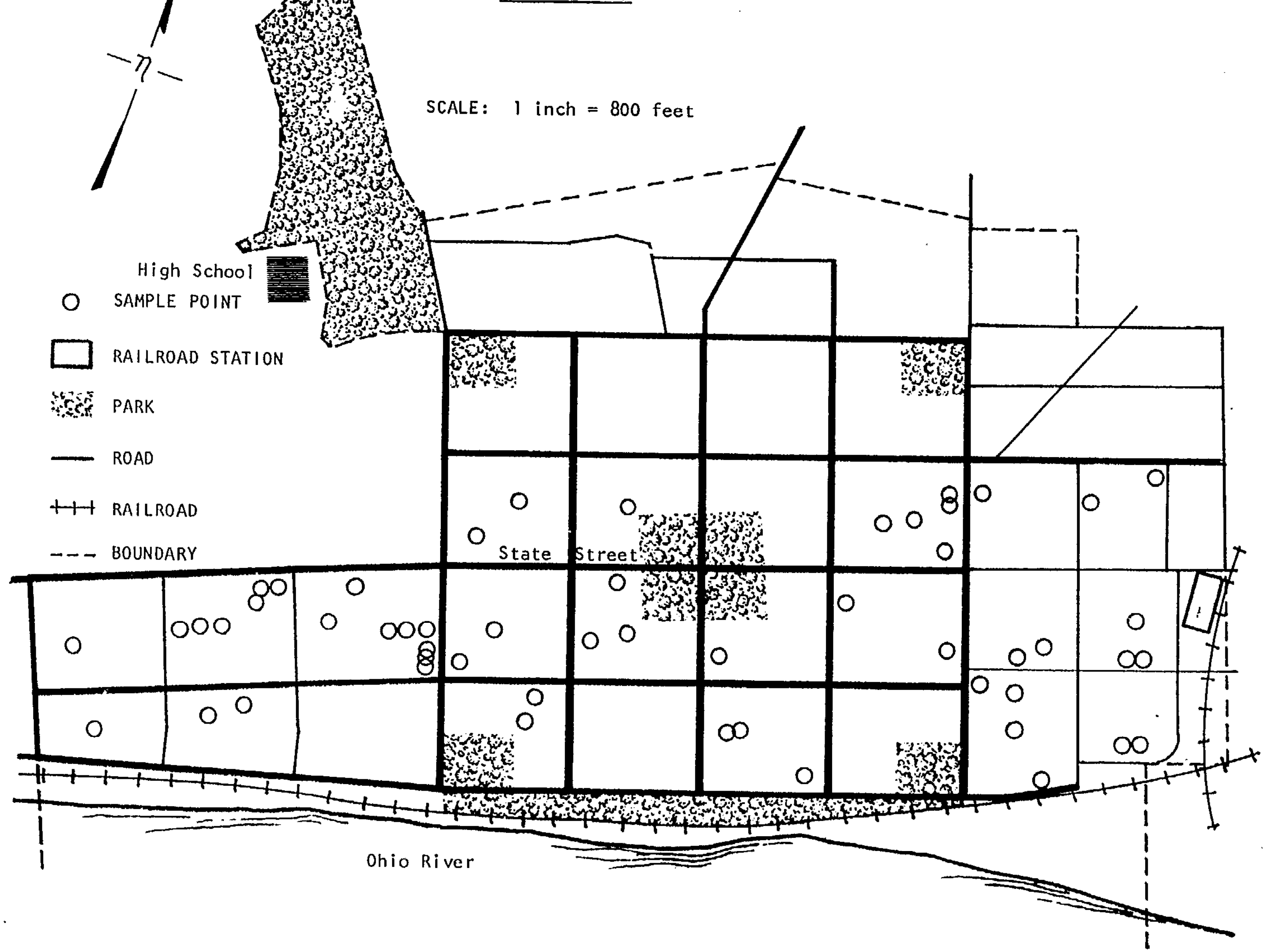
HISTORY OF THE ANALYSIS

Fifty-three (53) observations constitute the final sample used in the analysis. Observations located further than 3000 feet from the river were eliminated after preliminary computations, because it was felt that the effects of water quality changes did not extend beyond this distance.

We tested both linear and reciprocal functional forms of the water term. The reciprocal form of the distance to the Ohio River appeared to give the best description of value changes, but even it yielded inconclusive results.

Figure F-7

BEAVER, PENNSYLVANIA
(OHIO RIVER)



APPENDIX G

SEATTLE, WASHINGTON

(LAKE WASHINGTON)

Water conditions in Lake Washington were satisfactory prior to 1955. In 1955, the water quality in the lake started to worsen due to increasing discharges of municipal wastes and the accumulation of plant nutrients to critical levels. By the summer of 1962 the lake was severely degraded. Heavy blooms of brown algae and high coliform counts rendered the lake unsightly and unfit for recreation. Effluent discharge into Lake Washington was drastically curtailed subsequently in 1962, when the Seattle Metropolitan Council completed new sewage trunk lines and treatment plants and major waste outfalls were diverted out of the lake. Algae continued to make the water very turbid or cloudy until the period between 1966 and 1968, when the water quality improved markedly. By 1970, the water conditions had been restored to pre-1955 quality.

The temporary nature of the water pollution at Lake Washington distinguished it from other sites. Water quality worsened rapidly, was very bad for about four summers, and then improved rapidly.

APPENDIX H

REJECTED SITES

The following is a list of all water bodies which were investigated and then rejected as study sites:

1. Chain of Lakes
   (in Madison, Wisconsin)

2. Upper Mississippi River
   (downstream of St. Paul, Minnesota)

3. Lake Minnetonka
   (Minnesota)

4. Fairmont Chain of Lakes
   (Southern Minnesota)

5. Clarks Fork River
   (Montana)

6. South Platte River
   (Denver, Colorado)

7. Animas River
   (Durango, Colorado)

8. Lake Tahoe
   (California)

9. San Antonio River
   (San Antonio, Texas)

10. Sabine River
    (Eastern Texas)

11. Big Papillon Creek
    (Omaha, Nebraska)

12. Little Blue River
    (Kansas City, Missouri)

13. Wilson Creek
    (Springfield, Missouri)

14. Fox River
    (St. Charles, Illinois)

15. St. Joseph River
    (South Bend, Indiana)

16. Huron River
    (Ann Arbor, Michigan)

17. Ohio River
    (at Cincinnati, Ohio)

18. Mahoning River
    (Youngstown, Ohio)

19. Miami River
    (above Toledo, Ohio)

20. Muskingham River
    (Zanesville, Ohio)

21. Ottawa River
    (Ottawa, Ohio)

22. Little Walnut Creek
    (Columbus, Ohio)

23. Schuylkill River
    (Philadelphia, Pennsylvania)

24. Upper Brandywine Creek
    (Southeastern Pennsylvania)

25. Lake Erie
    (Sandusky, Ohio)

26. Lake Erie
    (Geneva-on-the-Lake, Ohio)

27. Lake Erie
    (Erie, Pennsylvania)

28. Upper Hudson River
    (New York)

29. Long Island Beaches
    (New York)

30. Whippany River
(Newark, New Jersey)

31. Lake Champlain
(New York and Vermont)

32. Hoosic River
(Southern Vermont)

33. Pemigewasset River
(New Hampshire)

34. Delaware River Estuary
(Delaware)

35. Potomac River
(Maryland)

36. James River
(Richmond, Virginia)

37. Roanoke River, Smith Mountain
Reservoir (Virginia)

38. St. Johns River
(Jacksonville, Florida)

39. Perdido Bay and Mobile Bay
(Alabama)

APPENDIX I

PUBLIC OPINION SURVEY

PUBLIC OPINION SURVEY

Hello. I'm ___________ with Opinion Research Corporation (west). We're talking with people in your neighborhood about water resources. May I speak with the (MALE) (FEMALE) head of your household?

1. First, do you own your home or do you rent here?

   Own 1 (CONTINUE)
   Rent 2 (THANK RESPONDENT AND TERMINATE)

2. Please try to imagine yourself in the particular situation described on this card. Read the description of the situation with me first and when we've finished, feel free to go back over any details which may not have been completely clear. (HAND RESPONDENT CARD A) Please read along with me on this card.

   Imagine that you are given a house overlooking a large lake. The water of the lake is clear, has a pleasing color, and has no odor.

   Although the water is perfectly safe, you are not allowed to use the lake for swimming or boating.

   Because of a chemical in the water there are no fish, birds, or other wildlife in the lake. (The chemical has no effect on people).

   In this situation, you are given a choice between the two following alternatives. YOU CANNOT HAVE BOTH. Which one would you choose?

   You Have a Choice Of

   Recreation Permit -- You would be given a recreation permit which allows you to use the lake for swimming and boating.

   Treatment for Wildlife -- A treatment would be applied to get rid of the chemical which keeps fish, birds and other wildlife from living in the lake. If the treatment were applied, wildlife would live in and around the lake in a very short time.

   Which one would you choose -- the Recreation Permit or the Treatment for Wildlife?

   Recreation Permit 1
   Treatment for Wildlife 2

2a. Was this a hard choice or an easy choice?

Hard Choice 1
Easy Choice 2

3. (HAND RESPONDENT CARD B).
Again, you are given a house overlooking a large lake. This time, the lake is cloudy, not a very pleasing color, and has an unpleasant odor.

Just as in the first case, there are no fish, birds or other wildlife in the lake because of a chemical in the water.

In this situation, you are given a choice between the two following alternatives. YOU CANNOT HAVE BOTH. Which one would you choose?

You Have a Choice Of

Treatment for Appearance -- A treatment would be applied to make the water clear, greatly improve the color, and remove any disagreeable odors. If the treatment were applied, the appearance and odor of the lake would greatly improve in a very short time.

Treatment for wildlife -- A treatment would be applied to get rid of the chemical which keeps fish, birds and other wildlife from living in the lake. If the treatment were applied, wildlife would live in and around the lake in a very short time.

Which one would you choose -- the Treatment for Appearance or the Treatment for Wildlife?

Treatment for Appearance 1
Treatment for Wildlife 2

3a. Was this a hard choice or an easy choice?

Hard Choice 1
Easy Choice 2

4. (HAND RESPONDENT CARD C).
Once again, you are given a house overlooking a large lake. The water is cloudy, not a very pleasing color, and has an unpleasant odor.

Although the water is perfectly safe, you are not allowed to use the lake for swimming or boating.

In this situation you are given a choice between the two following alternatives. YOU CANNOT HAVE BOTH. Which one would you choose?

You Have a Choice Of

Treatment for Appearance -- A treatment would be applied to make the water clear, greatly improve the color, and remove any disagreeable odors. If the treatment were applied, the appearance and odor of the lake would greatly improve in a very short time.

Recreation Permit -- You would be given a recreation permit which allows you to use the lake for swimming and boating.

Which one would you choose -- the Treatment for Appearance or the Recreation Permit?

Treatment for Appearance 1
Recreation Permit 2

4a. Was this a hard choice or an easy choice?

Hard Choice 1
Easy Choice 2

5. In describing these three situations we talked about several things that affect the quality of a body of water -- things like the way it looks and smells, whether there are fish and other wildlife there, and the ability to use the water for recreation.

(HAND RESPONDENT Q.5 ANSWER SHEET).
This page lists four categories of water quality. Suppose you have a total of 100 votes to distribute among these categories. How you place your votes shows how important it would be to have each item in a river, bay, or other body of water located near where you live.

The more important you feel any item is, the more votes you should give to that item. The less important you feel an item is, the fewer votes you should give that item.

Remember, you have a total of 100 votes altogether.

Are there any questions?

Please read the categories carefully and write in the number of votes you want to assign each category in the space below it.

6. (HAND RESPONDENT CARD D).
The appearance and attractiveness of a (RIVER, BAY) depends on the color of the water, the odor, the clearness or cloudiness of the water, and the amount of floating debris or oil. Which one of these things about a (RIVER, BAY) would be most important to you? (READ CATEGORIES. WRITE IN "1" NEXT TO THE ITEM NAMED MOST IMPORTANT. RECORD BELOW).

7. Which would be next most important to you? (WRITE IN "2" NEXT TO ITEM NAMED AS NEXT MOST IMPORTANT).

_____ Color of the water

_____ Odor of the water

_____ Clearness of the water

_____ Absence of floating debris or oil on the water

8. If you had 100 votes, how would you distribute them among these aspects of water appearance and attractiveness in terms of importance to you?

_____ Color of the water

_____ Odor of the water

_____ Clearness of the water

_____ Absence of floating debris or oil on the water

(TAKE BACK CARD D).

9. Does this voting system let you accurately explain your feelings about the various aspects of water attractiveness and appearance?

Yes 1 (GO ON TO Q.10)
No 2 } (ASK Q.9a)
Don't Know 3

9a. Why is that? Any other reasons you say that?

10. Do you do any boating?

Yes 1 (ASK Q.11)
No 2 (SKIP TO Q.12)

11. Do you do any boating on the (NAME OF RIVER, BAY)?

Yes 1 (ASK Q.11a)

No 2 (ASK Q.11b)

11a. Where on the (NAME OF RIVER, BAY) is that?

11b. Would you do any boating on the (NAME OF RIVER, BAY)?

Yes 1 (ASK Q.11c)

No 2 (ASK Q.11d)

11c. Where on the (NAME OF RIVER BAY) would that be?

11d. Why is that? PROBE: Any other reasons you wouldn't do any boating on the (NAME OF RIVER BAY)?

12. Compared to 1960, do you think there is more, less or about the same amount of boating on the (NAME OF RIVER, BAY)? (IF RESPONDENT IN AREA LESS THAN 13 YEARS: Just your impression.)

More	1
Less	2
About the same	3
Don't Know,	4

Yes 1 (ASK Q.14)
No 2 (SKIP TO Q.15)

14. Do you swim in the (NAME OF RIVER, BAY)?

Yes 1 (ASK Q.14a) → 14a. Where in the (NAME OF RIVER, BAY) is that?

No 2 (ASK Q.14b)

14b. Would you go swimming in the (NAME OF RIVER, BAY)?

Yes 1 (ASK Q.14c) No 2 (ASK Q.14d)

14c. Where on the (NAME OF RIVER, BAY) would that be?	14d. Why is that? PROBE: Any other reasons you wouldn't do any swimming in the (NAME OF RIVER, BAY)?

15. Would you say there is more, less or about the same amount of swimming in the (NAME OF RIVER, BAY) as there was in 1960?

More	1
Less	2
About the same	3
Don't Know	4

16. Do you do any fishing?

Yes 1 (ASK Q.17)
No 2 (SKIP TO Q.18)

17. Do you do any fishing on the (NAME OF RIVER, BAY)?

Yes 1 (ASK. Q.17a) → 17a. Where on the (NAME OF RIVER, BAY) is that?

No 2 (ASK Q.17b)

17b. Would you do any fishing on the (NAME OF RIVER, BAY)?

Yes 1 (ASK Q.17c) No 2 (ASK Q.17d)

17c. Where on the (NAME OF RIVER, BAY) would that be?

17d. Why is that? PROBE: Any other reasons you wouldn't do any fishing on the (NAME OF RIVER, BAY)?

18. Would you say there are more, less or about the same amount of fish in the (NAME OF RIVER, BAY) than there were in 1960?

More fish	1
Less fish	2
About the same	3
Don't Know	4

19. Do you think there are more, less or about the same number of water birds here now as there were 10 or 15 years ago?

More	1
Less	2
About the same	3
Don't know	4

20. How long have you lived in the ______________________ area?

Less than one year	1	8 years to less than 9 years	9
One year to less than 2 years	2	9 years to less than 10 years	10
2 years to less than 3 years	3	10 years to less than 15 years	11
3 years to less than 4 years	4	15 years to less than 20 years	12
4 years to less than 5 years	5	20 years or more	13
5 years to less than 6 years	6		
6 years to less than 7 years	7		
7 years to less than 8 years	8		

21. Do you think there has been any change in the quality of the water of the (NAME OF RIVER, BAY) since 1960? (IF RESPONDENT IN AREA LESS THAN 13 YEARS) We are interested in your impression of whether there have been any changes, even if you weren't here then.

Yes, change	1	(ASK Q.22 AND Q.23)
No, no change	2	(SKIP TO Q.24)
Don't Know	3	(SKIP TO Q.24)

22. Would you say the water quality is better or worse than it was then?

Better	1
Worse	2

23. Would you say much, somewhat or only slightly (ANSWER IN Q.22)?

Much better	1
Somewhat better	2
Only slightly better	3
Only slightly worse	4
Somewhat worse	5
Much worse	6

24. Would you say the water of the (NAME OF RIVER, BAY) nearest to where you live looks different now than it did say, 10 or 15 years ago? We are interested in your impression of whether or not the water looks different now than it did then.

Yes	1	(ASK Q.25 AND Q.26)
No	2	(SKIP TO Q.27)
Don,t Know	3	(SKIP TO Q.27)

25. How would you describe this difference? How else?

26. (HAND RESPONDENT CARD E).
I'll read you a few statements about how the water of the (NAME OF RIVER, BAY) looks now compared with 10 or 15 years ago. Looking at this card, please tell me whether you agree or disagree with each statement and how strongly you agree or disagree. Remember, we are interested in your impressions, even if you didn't live here at that time.

	Agree Completely	Agree Somewhat	Neither Agree Nor Disagree	Disagree Somewhat	Disagree Completely
The water is clearer now than it was	1	2	3	4	5
There is less floating debris and refuse than there was	1	2	3	4	5
be water smells better	1	2	3	4	5
There seems to be more wildlife now	1	2	3	4	5
There are fewer dead fish now than there were	1	2	3	4	5
The color of the rater is better now	1	2	3	4	5

27. What are you usually doing when you get your best look at the water of the (NAME OF RIVER, BAY)? (DO NOT READ CATEGORIES).

Looking out window of home	1
Walking by	2
Driving by	3
Fishing	4
Other (SPECIFY)	5

____

28. How often do you get close enough to the (NAME OF RIVER, BAY) to see into the water:

More than 10 times a year	1
Five to ten times a year	2
Three to under five times a year	3
Once or twice a year	4
Less than once a year	5

29. Just a few background questions for statistical purposes and then we'll be through. Did you participate in the decision to buy your home or was the decision made entirely by someone else?

Respondent participated in decision	1
Decision entirely by someone else	2

30. (HAND RESPONDENT CARD F) Which of the categories on this card includes your age? (CIRCLE CODE LETTER)

APPENDIX J

ANNOTATED BIBLIOGRAPHY

INTRODUCTION

We have surveyed and listed the most important sources concerning the demand for property near the water, the effect of water pollution on property values, and the demand for water-based recreation. While some provide background and perspective, others treat the respective topics specifically. Particularly significant are the empirical works on the determination of property values. Each title is briefly annotated, and we have confined our introductory remarks to a few very significant works.

The price that a piece of property will command in the market depends not only on its own characteristics but also on those of the neighborhood in which it is located. Three papers explore the effect of the various physical and demographic variables upon property values: "Effects of Race and other Demographic Factors on the Values of Single Family Homes," by Martin Bailey; "The Determinants of Residential Land Values," by Eugene Brigham; and "Land Value and Land Development Influence Factors: An Analytical Approach for Examining Policy Alternatives," by S.F. Weiss.

Other references concern the relationship between the existence and quality of water resources and the value of adjacent properties. These are: "Water Quality and the Value of Homesites on the Rockaway River, N.J.," by J. Beyer; "Lakeshore Property Values: A Guide to Public Investment in Recreation," by Elizabeth David; "The Influence of Reservoir Projects on Land Values," by Jack Knetsch; and "Estuarine Clean Water Cost-Benefit Studies," by R. Stone. Of special interest are the studies by Elizabeth David and Jack Knetsch whose substantiations of the effect of water on property values offer an excellent point of departure for our study. Both papers employ essentially cross-sectional techniques, which we supplement by providing the needed time dimension with a before-and-after approach.

BIBLIOGRAPHY

Alonso, William, *Location and Land Use*, Cambridge, Harvard University Press, 1964.
This book treats the the theoretical foundations of rent and related topics, and provides good background information for a study of land value. Included are discussions and some applications of the economics of urban land, household equilibrium, and residential bid price curves.

Bailey, Martin J., "Effects of Race and Other Demographic Factors on the Values of Single Family Homes," *Land Economics*, Vol. 42, May 1966, pp. 215-220.
Discussion and multiple regression analysis of the effect demographic and physical factors have on the value of residential home. The study demonstrates the importance of considering "community" variables in a land value regression equation.

Beardsley, Wendell, "Bias and Noncomparability in Recreation Evaluation Models," *Land Economics,* Vol. 47, May 1971, pp. 175-81.
Discussion of the sources of bias in estimating recreation demand by the travel cost method. The article supplements Clawson's work on this subject, and provides good background information.

Beyer, J., "Water Quality and the Value of Homesites on the Rockaway River, N.J." New Brunswick, Water Resources Research Institute, Rutgers-The State University, 1969.
An exploratory investigation of the relationship between the river and real estate values on the Rockaway River. No statistical correlation analysis was performed; only questionnaires were given to a few realtors and residents. The paper concludes that a relationship does exist and suggests that a regression analysis would be a good method of investigation.

Biniek, Joseph P., "Economics of Water Pollution," Washington, D.C., U.S. Department of Agriculture, 1969.
This paper provides good background information on water pollution. public concern, externalities, costs of pollution control, and agricultural pollution.

Brigham, Eugene F., "The Determinants of Residential Land Values," *Land Economics,* Vol. 41, November 1965, pp. 325-330.
Presenting the findings of a land value study of Los Angeles County, this article serves as a good reference on the important variables for a land value regression equation.

Brodsky, Harold, "Residential Improvement Values: Central City?" *Land Economics,* Vol. 46, August 1970, pp. 229-246.
This article gives a good theoretical survey of some of the relevant variables in determining rents. Multiple regression is used to demonstrate the relationship between land values, improvement values and distance to the central business district. Good reference for selecting variables for a regression analysis.

Clawson, Marion, and J.L. Knetsch, *Economics of Outdoor Recreation,* Resources for the Future, Inc., Baltimore, The Johns Hopkins Press, 1966.
This book provides an intensive discussion and good background information on the demand for outdoor recreation, emphasizing the travel cost method of estimation.

Crocker, Thomas D., "Urban Air Pollution Damage Functions: Theory and Measurement," Environmental Protection Agency, Office of Air Programs, June 1971.
This cross-sectional study uses FHA value assessment data to test relationships between pollution levels and property values. Local tax assessments were found to be poor proxies for actual market sales prices, while FHA assessments were good proxies. The hypothesis that land values are more sensitive to air pollution dosages than are the values of land improvements was also supported by the results.

David, Elizabeth L., "The Exploding Demand for Recreational Property," *Land Economics,* Vol. 45, May 1969, pp. 206-217.
An analysis of the trend in recreational property values over time (1952, 1957,

1962), this paper shows the substantial gains accrued to private owners of waterfront property. These results lend support to the contention that water quality changes should affect property values.

David, Elizabeth L., "Lakeshore Property Values: A Guide to Public Investment in Recreation," *Water Resources Research*, Vol. 4, August 1968, pp. 697-707.
A study of lakeshore property values using multiple regression analysis. Significant variables include: characteristics of shore area, proximity to population centers, presence of other lakes in the area, and water quality. Results support the hypothesis that changes in water quality affect nearby property values.

Dee, Norbert, et al., "Environmental Evaluation System for Water Resource Planning," Report for the Bureau of Reclamation, Batelle Columbus Laboratories. January 1973.
The report includes a section on assigning an environmental importance weight to the following water quality parameters: dissolved oxygen, temperature, fecal coliforms, turbidity, pH, BOD, nitrates. phosphates, and total solids. Parameter weights are based on the judgment of experts.

Dougal, Merwin D., E. Robert Baumann, and John F. Timmons, "Physical and Economic Factors Associated with the Establishment of Stream Water Quality Standards," Volume I, Iowa State Water Resources Research Institute, March 1970.
An historical review of water pollution problems, this study includes identification and effects of potential pollutants, application of water quality standards, mathematical models of stream behavior and economic aspects. The paper gives a general background to the economic dimension of water pollution problems including the benefits and costs of improving water quality.

Hammer, Thomas R., et al., "The Effect of Large Urban Park on Real Estate Value," RSRI Discussion Paper Series No. 51, September 1971.
This cross-sectional study develops a logarithmic regression equation in an attempt to measure the value of Pennypack Park in Philadelphia. A significant relationship exists between residential sales prices and access to the park, substantiating the hypothesis that public parks have a positive effect on adjacent land values.

Jarrett, Henry, ed., *Environmental Quality In a Growing Economy,* Baltimore, Johns Hopkins Press.
Contents include: resources development, environment and health, externalities, research problems, welfare economics, public attitude, policies, along with good background information on environmental economics.

Keiper, Joseph, and others, *Theory and Measurement of Rent.* Philadelphia. Chilton Co., 1961.
This book discusses various aspects of rent theory, including the important variables in land valuation. In addition, the book covers the problems and techniques of measuring property and land values, which are integral to formulating a land value regression equation.

Kitchen. James W., "Land Values Adjacent to an Urban Neighborhood Park," *Land*

Economics, Vol. 43, No. 3, August 1967, pp. 357-360.
This paper tests the hypothesis that the value of adjacent properties diminishes with distance from neighborhood parks. No significant relationship was found, using either assessed values (land plus improvements) or sales prices; however, a significant negative correlation was established between assessed land values (assessed improvement values were excluded) and distance from the park.

Kneese, Allen V., ed., *Water Research,* Resources for the Future, Inc., Baltimore. Johns Hopkins Press, 1965.
This study includes discussions of the problems of discounting and public investment criteria, social valuation of water recreational facilities, and comparisons of methods of recreation evaluation, as well as of public goods, externalities, and regression analysis, as they relate to recreation.

Knetsch, Jack L., "The Influence of Reservoir Projects on Land Values," *Journal of Farm Economics,* Vol. 46, February 1964, pp. 520-538.
In this study of the relation between property values and the presence of nearby lakes, significant differences in values were found to be attributable to the lakes. Several characteristics of the lakes and sites also seemed to influence property values. The study is also a useful reference on the relevant variables for a land value-water quality regression analysis.

Knetsch, Jack L., "Land Values and Parks in Urban Fringe Areas," *Journal of Farm Economics,* Vol. 44, pp. 1718-1729.
This article discusses, the method of using land-value surplus on property adjacent to urban parks for estimating the social benefits of these parks. It also serves as a good supporting reference.

Little, Arthur D., Inc., *Tourism and Recreation: A State-of-the-Art Study,* Washington, D.C., U.S. Department of Commerce, 1967.
The study provides background on current techniques of economic development and planning as related to tourism and recreation. It should prove useful as a partial check-list of relevant considerations in connection with recreation demand.

McClellan, Keith, and Elliott A. Medrich, "Outdoor Recreation: Economic Considerations for Optimal Site Selection and Development," *Land Economics,* Vol. 45, May 1969, pp. 174-182.
This article includes a general review of methods currently used to estimate demand for outdoor recreation, and proposes a more "systematic" method for dealing with location and development of recreation facilities. It provides good background information on the demand for water-based recreation.

Milliman, J.W., "Land Values as Measures of Primary Irrigation Benefits," *Journal of Farm Economics,* Vol. 41, No. 2, May 1959, pp. 234-243.
This analysis compares the "budget" method (i.e., discounting future net benefits) with the land value approach for estimating irrigation benefits. The author gives a concise presentation of the major issues, concluding that since both methods involve a number of theoretical and empirical problems, the best choice depends on the particular circumstances surrounding the case.

Nemerow, Nelson E., "Benefits of Water Quality Enhancement," Washington, D.C., Environmental Protection Agency, Water Quality Office, December 1970.
The paper proposes a method for the development and application of a pollution index. It also discusses various methods for measuring the total dollar benefits from water pollution control, including the increase in adjacent property values.

Perloff, Harvey S., ed., *The Quality of the Urban Environment,* Resources for the Future, Inc., Baltimore, The Johns Hopkins Press, 1969.
Chapter 2, entitled "Pollution and Environmental Quality," discusses pollution from a materials balance viewpoint. Chapter 7, "The Value of Urban Land," gives the theoretical and empirical basis of urban land values. Both chapters provide a useful framework in which to view the respective topics.

Ridker, Ronald G., and John A. Henning, "The Determinants of Residential Property Values with Special Reference to Air Pollution," *Review of Economics and Statistics,* May 1967, pp. 246-257.
The study uses multiple regression analysis in an attempt to isolate the effects of air pollution, property characteristics, and other factors on property values. It points out some of the important variables that should be considered for a land value regression equation.

Sickler, David W., "On the Uses and Abuses of Economic Science in Evaluating Public Outdoor Recreation," *Land Economics,* Vol. 42, November 1966, pp. 485-494.
This is a critique of the travel cost method of estimating demand for outdoor recreation. It points out the limitations and assumptions of the basic model, emphasizing the problems of income distribution effects. The article supplements Clawson's work on recreation demand.

Stone, R., and H. Friedland, "Estuarine Clean Water Cost-Benefit Studies," Fifth International Water Pollution Research Conference, San Francisco, 1970.
A socio-economic cost-benefit analysis was made of the beneficial uses of San Diego Bay in relation to the improvement of the Bay's water quality in the 1960's. Changes in assessed valuations of comparable residential land parcels were analyzed based on their distance from the Bay. Results showed a positive correlation between water quality and land values.

Thueson, Gerald J., *A Study of Public Attitudes and Multiple Objective Decision Criteria for Water Pollution Control Projects,* OWRR Project No. A-028-GA, Georgia Institute of Technology, October 1971.
This report presents a method for assigning non-economic values to changes in water quality parameters for different types of water use (recreation, water supply, effluent disposal, etc.). Only discussion and no empirical results are given.

Walker, William R., ed., *Economics of Air and Water Pollution,* Blacksburg, Water Resources Research Center, Bulletin 26.
The seventeen papers, including "The Measurement of Economic Losses from Uncompensated Externalities," by T.D. Crocker, give a good overall treatment of economic side effects.

Weiss, S.F., T.G. Donnelly, and E.J. Kaiser, "Land Value and Land Development Influence Factors: An Analytical Approach for Examining Policy Alternatives," *Land Economics*, Vol. 42, May 1966, pp. 230-232.

The authors examine fourteen variables affecting land values, using the multiple regression technique. The study provides useful information concerning the selection of important variables influencing land values for a regression analysis.

APPENDIX K

CASE STUDY DATA AND CORRELATION COEFFICIENTS

Table K-1. CORRELATION COEFFICIENTS - CORONADO SITE

	V_{64}	ΔV	$\Delta V/V_{64}$	$4000-d_w$	Dist. /Bridge	Dist. /Orange	Dist. /Navy	Lot Area	Dist. /School
V_{64}	1	.81	.10	.03	.14	-.06	.17	.47	.16
ΔV		1	.63	.16	-.05	-.16	.37	.35	.27
$\Delta V/V_{64}$			1	.18	-.28	.19	.46	.01	.17
$4000 - d_w$				1	-.41	-.27	.21	-.13	.64
Distance to Bridge access					1	.76	-.58	.27	-.03
Distance to Orange Ave.						1	-.36	.27	.00
Distance to Navy access							1	-.14	.30
Lot Area								1	.02
Distance to nearest School									1

Table K-2. CORRELATION COEFFICIENTS - CLACKAMAS COUNTY URBAN

	V_{63} Assessed	ΔV	$\Delta V/V_{63}$	$1/(d_W+1000)$ $-.0002$	Dist. /Water	Dist. /Park	Dist. /School	Dist. /Shopping	Dist. /Hwy 99E	Dist. /Portland	Lot Area
V_{63} Assessed	1	.90	-.30	.53	-.37	-.02	.18	.22	.30	.21	.25
ΔV		1	.08	.48	-.34	-.03	.04	.17	.23	.15	.43
$\Delta V/V_{63}$			1	-.04	-.01	-.04	-.16	-.01	-.11	-.01	.24
$1/(d_W+1000)-.0002$				1	-.91	.20	.45	.64	.70	.36	.10
Distance to Water					1	-.22	-.42	-.75	-.75	-.36	-.03
Distance to Park						1	.03	.21	.14	-.53	-.00
Distance to nearest School							1	.57	.19	.59	.05
Distance to Shopping Center								1	.32	.49	.06
Distance to Highway 99E									1	.35	-.08
Distance to Portland										1	-.03
Lot Area											1

Table K-3. CORRELATION COEFFICIENTS - CLACKAMAS COUNTY RURAL SITE

	V_{60}	ΔV/acre	$\Delta V/V_{60}$	Distance to Water	$1/(d_w+500)-.00022$	Dist. /Boat Ramp	Dist. /Bridge	Dist. /Portland	Dist. /Salem	Dist. /Town	Waterfront footage	Lot Area
V_{60}	1	-.14	-.23	.23	.02	.00	-.01	-.08	.14	-.11	.32	.50
ΔV/acre		1	.22	-.53	.71	-.31	-.47	-.38	.37	-.09	.21	-.51
$\Delta V/V_{60}$			1	-.07	.16	-.20	.04	.10	-.06	.23	.41	.17
Distance to Water				1	-.82	.16	.04	-.03	.04	.05	-.38	.59
$1/(d_w+500)-.00022$					1	-.19	-.27	-.20	.21	-.08	.52	-.50
Distance to nearest Boat Ramp						1	.33	.28	-.22	-.18	.12	.15
Distance to nearest Bridge							1	.94	-.80	.07	.17	.47
Distance to Portland								1	-.92	.30	.22	.45
Distance to Salem									1	-.55	-.17	-.37
Distance to nearest Town										1	.06	.17
Waterfront footage											1	.19
Lot Area												1

Table K-4. CORRELATION COEFFICIENTS - CHARLESTON SITE

	ΔV	$\Delta V/V_{60}$	V_{60}	$(1/d_W) - .0005$	Dist. /Water	Dist. /School	Dist. /Mac C.	Dist. /Bridge	Waterfront	Lot Area
ΔV	1	.90	-.26	.25	-.23	.01	.22	.06	.25	.25
$\Delta V/V_{60}$		1	-.23	.15	-.16	-.04	.22	.00	.15	.17
V_{60}			1	.25	-.18	-.32	.33	-.11	.24	.61
$(1/d_W) - .0005$				1	-.61	.17	.64	.16	.99	.72
Distance to Water					1	-.13	-.85	-.11	-.57	.45
Distance to nearest School						1	.02	.74	.16	-.07
Distance to Mac Corkle Ave.							1	.19	.61	.57
Distance to Bridge access								1	.16	.13
Waterfront Dummy Variable									1	.72
Lot Area										1

Table K-5. CORRELATION COEFFICIENTS - DUNBAR SITE

	V_{60}	ΔV	$\Delta V/V_{60}$	Dist. /Water	$(1/d_w)-.0005$	Dist. /School	Dist. /C.B.D.	Dist. /Bridge	Dist. /Hwy	Dist. /R.R.	Lot Area
V_{60}	1	-.60	-.55	-.28	.37	-.06	.02	.04	.02	.19	.44
ΔV		1	.93	.25	-.20	.13	-.03	-.02	-.02	-.06	-.10
$\Delta V/V_{60}$			1	.26	-.14	.20	-.13	-.11	-.12	.06	-.02
Distance to Water				1	-.73	.04	-.34	-.32	-.34	-.17	-.58
$(1/d_w) - .0005$					1	.22	.11	.13	.12	.28	.77
Distance to nearest School						1	-.65	-.66	-.66	.59	.06
Distance to Central Business District							1	.99	.99	-.68	.20
Distance to Bridge access								1	.99	-.61	.24
Distance to Highway access									1	-.66	.21
Distance to Railroad										1	.31
Lot Area											1

Table K-6. CORRELATION COEFFICIENTS - BEAVER SITE

	ΔV	$\Delta V/V_{60}$	V_{70}	Dist. /Water	$(1/d_W)-.0005$	Dist. /State St.	Dist. /Agnew	Dist. /R.R.	Dist. /H.S.	Dist. /Park	Lot Area
ΔV	1	.88	.32	.08	-.05	-.18	.20	.06	-.02	.23	-.17
$\Delta V/V_{60}$		1	.18	.14	-.08	-.21	-.00	.03	-.05	.13	-.15
V_{70}			1	-.30	.42	.31	.31	-.06	.25	-.10	.44
Distance to Water				1	-.21	-.62	-.44	-.19	-.12	-.08	-.21
$(1/d_W)-.0005$					1	.74	.42	.03	.29	.09	.26
Distance to State Street						1	.05	-.19	.40	-.31	.15
Distance to Agnew Sq.							1	.29	.03	.59	.14
Distance to Railroad Stn								1	-.91	.44	-.01
istance to High School									1	-.24	.07
stance to near- corner Park										1	-.05
Area											1

Table K-7. SAMPLE DATA - CORONADO SITE

Observation Number	V_{64}	T_{64}	V_{71}	T_{72}	Distance to Bridge access (ft.)	Distance to Orange Ave. (ft.)	Distance to nearest School (ft.)	Lot Area (sq. ft.)	Distance to Navy access (ft.)	Distance to Water (ft.)
1	.27952E+05	.37371E+03	.32500E+05	.66110E+03	.34000E+04	.22700E+04	.34000E+04	.70000E+04	.26400E+04	.21000E+03
2	.24593E+05	.32881E+03	.34000E+05	.56487E+03	.42500E+04	.28100E+04	.23800E+04	.70000E+04	.14900E+04	.52000E+03
3	.17768E+05	.23755E+03	.26000E+05	.52926E+03	.43100E+04	.29000E+04	.25500E+04	.70000E+04	.16600E+04	.32000E+03
4	.21180E+05	.28318E+03	.25000E+05	.40176E+03	.47400E+04	.32300E+04	.20900E+04	.35000E+04	.11900E+04	.58000E+03
5	.31364E+05	.41934E+03	.48900E+05	.78139E+03	.34700E+04	.20750E+04	.26900E+04	.70000E+04	.19200E+04	80000E+03
6	.30714E+05	.41065E+03	.42500E+05	.70970E+03	.33700E+04	.20800E+04	.29200E+04	.70000E+04	.22500E+04	.53000E+03
7	.42307E+05	.56564E+03	.80000E+05	.98036E+03	.28700E+04	.17200E+04	.27400E+04	.10500E+05	.26600E+04	.69000E+03
8	.45015E+05	.60185E+03	.73000E+05	.10095E+04	.26200E+04	.14900E+04	.25500E+04	.70000E+04	.27200E+04	.83000E+03
9	.23185E+05	.30998E+03	.31500E+05	.64955E+03	.22900E+04	.12800E+04	.23700E+04	.50750E+04	.30800E+04	.94000E+03
10	.23185E+05	.30998E+03	.37500E+05	.92621E+03	.19300E+04	.13200E+04	.19000E+04	.52500E+04	.35600E+04	.10000E+04
11	.54603E+05	.73005E+03	.63000E+05	.14434E+04	.20700E+04	.16400E+04	.18200E+04	.10500E+05	.37900E+04	.70000E+03
12	.38894E+05	.52001E+03	.52000E+05	.79244E+03	.46700E+04	.31400E+04	.18800E+04	.70000E+04	.98000E+03	.82000E+03
13	.16359E+05	.21872E+03	.19000E+05	.38396E+03	.46700E+04	.31400E+04	.18200E+04	.35000E+04	.92000E+03	.48000E+03
14	.27302E+05	.36502E+03	.30000E+05	.60144E+03	.36400E+04	.21300E+04	.20600E+04	.45000E+04	.13400E+04	.12600E+04
15	.19772E+05	.26435E+03	.22500E+05	.36086E+03	.31200E+04	.17300E+04	.26600E+04	.35000E+04	.19400E+04	.11300E+04
16	.30010E+05	.40124E+03	.41500E+05	.74578E+03	.30400E+04	.16200E+04	.23900E+04	.70000E+04	.21200E+04	.10800E+04
17	.34831E+05	.46569E+03	.53500E+05	.76984E+03	.26600E+04	.13300E+04	.22400E+04	.70000E+04	.24600E+04	.12000E+04
18	.23997E+05	.32084E+03	.28500E+05	.46864E+03	.24900E+04	.12700E+04	.23200E+04	.56000E+04	.26800E+04	.10800E+04
19	.24539E+05	.32809E+03	.32500E+05	.45613E+03	.24000E+04	.10800E+04	.20700E+04	.42000E+04	.26300E+04	.13200E+04
20	.24702E+05	.33026E+03	.32000E+05	.46864E+03	.22300E+04	.92500E+03	.19700E+04	.56000E+04	.29400E+04	.14000E+04
21	.18472E+05	.24697E+03	.22000E+05	.36086E+03	.14400E+04	.76000E+03	.17300E+04	.60000E+04	.35500E+04	.16500E+04
22	.18418E+05	.24625E+03	.25500E+05	.43303E+03	.12900E+04	.14500E+04	.11400E+04	.22500E+04	.42250E+04	.11800E+04
23	.23239E+05	.31070E+03	.35000E+05	.62549E+03	.17200E+04	.16200E+04	.58000E+03	.70000E+04	.46800E+04	.16000E+04
24	.21126E+05	.28246E+03	.29000E+05	.50521E+03	.89000E+03	.17200E+04	.55000E+03	.35000E+04	.47500E+04	.14000E+04
25	.28006E+05	.37444E+03	.27000E+05	.64955E+03	.43400E+04	.28200E+04	.11400E+04	.70000E+04	.40000E+03	.17200E+04
26	.37540E+05	.50191E+03	.35000E+05	.87762E+03	.43400E+04	.28200E+04	.11700E+04	.70000E+04	.41000E+03	.16800E+04
27	.39544E+05	.52870E+03	.46000E+05	.81795E+03	.43400E+04	.28200E+04	.12000E+04	.70000E+04	.42000E+03	. .6400E+04
28	.32719E+05	.43745E+03	.37000E+05	.72172E+03	.38200E+04	.22300E+04	.16600E+04	.70000E+04	.10300E+04	.16200E+04
29	.24268E+05	.32447E+03	.16000E+05	.52926E+03	.32200E+04	.16300E+04	.18800E+04	.43500E+04	.16100E+04	.17500E+04
30	.23185E+05	.30998E+03	.30000E+05	.51676E+03	.28800E+04	.13750E+04	.19250E+04	.42500E+04	.19900E+04	.15500E+04
31	.26056E+05	.34837E+03	.34500E+05	.52926E+03	.10100E+04	.81000E+03	.14200E+04	.70000E+04	.39000E+04	.18700E+04
32	.27952E+05	.37371E+03	.37000E+05	.60144E+03	.10300E+04	.83000E+03	.14000E+04	.67500E+04	.39000E+04	.18200E+04
33	.21180E+05	.28318E+03	.31000E+05	.52926E+03	.10100E+04	.91000E+03	.13300E+04	.45000E+04	.39600E+04	.17600E+04
34	.50486E+05	.67500E+03	.68500E+05	.13107E+04	.84000E+03	.10300E+04	.11600E+04	.95000E+04	.41250E+04	.18000E+04
35	.28656E+05	.38313E+03	.36500E+05	.60144E+03	.58000E+03	.14000E+04	.77500E+03	.52000E+04	.45300E+04	.17800E+04
36	.37540E+05	.50191E+03	.46000E+05	.10104E+04	.32000E+03	.17100E+04	.60000E+03	.88000E+04	.49200E+04	.19300E+04
37	.36186E+05	.48380E+03	.36000E+05	.93824E+03	.47900E+04	.32300E+04	.41000E+03	.10130E+05	.66000E+03	.24500E+04
38	.33423E+05	.44686E+03	.48000E+05	.79390E+03	.51500E+04	.35800E+04	.46000E+03	.14450E+05	.52000E+03	.22400E+04
39	.21180E+05	.28318E+03	.29500E+05	.42053E+03	.43500E+04	.27600E+04	.10100E+04	.45000E+04	.49000E+03	.19200E+04
40	.23997E+05	.32084E+03	.29500E+05	.46864E+03	.40000E+04	.23800E+04	.12600E+04	.56000E+04	.84000E+03	.20100E+04
41	.24593E+05	.32881E+03	.33500E+05	.55236E+03	.36400E+04	.20300E+04	.18700E+04	.52500E+04	.12200E+04	.21800E+04
42	.35481E+05	.47439E+03	.47000E+05	.72172E+03	.30250E+04	.14400E+04	.13750E+04	.70000E+04	.18200E+04	.22800E+04
43	.14301E+05	.19120E+03	.21000E+05	.33640E+03	.26600E+04	.10250E+04	.11100E+04	.35000E+04	.21800E+04	.23600E+04
44	.25243E+05	.33750E+03	.33000E+05	.46864E+03	.24800E+04	.97000E+03	.87000E+03	.30000E+04	.24600E+04	.26100E+04
45	.30714E+05	.41065E+03	.40500E+05	.64859E+03	.17300E+04	.14000E+03	.12200E+04	.63000E+04	.30750E+04	.23100E+04
46	.19122E+05	.25566E+03	.19000E+05	.45709E+03	.13100E+04	.38000E+03	.11800E+04	.35000E+04	.35200E+04	.25800E+04
47	.24593E+05	.32881E+03	.36500E+05	.69767E+03	.10100E+04	.79000E+03	.14000E+04	.70000E+04	.39300E+04	.27000E+04
48	.25243E+05	.33750E+03	.30000E+05	.62453E+03	.41200E+04	.25700E+04	.11400E+04	.70000E+04	.13000E+04	.27700E+04
49	.22481E+05	.30056E+03	.27000E+05	.52926E+03	.38900E+04	.23200E+04	.14200E+04	.56000E+04	.15000E+04	.28600E+04
50	.22210E+05	.29694E+03	.25500E+05	.44458E+03	.37000E+04	.21500E+04	.18800E+04	.56000E+04	.14700E+04	.26100E+04
51	.22643E+05	.30274E+03	.27500E+05	.50521E+03	.37000E+04	.21500E+04	.18800E+04	.56000E+04	.15000E+04	.26600E+04
52	.22481E+05	.30056E+03	.26000E+05	.45709E+03	.37000E+04	.21500E+04	.18800E+04	.56000E+04	.15300E+04	.27200E+04
53	.12947E+05	.17310E+03	.16500E+05	.32430E+03	.33000E+04	.17500E+04	.12500E+04	.35000E+04	.17700E+04	.27500E+04
54	.13651E+05	.18251E+03	.11000E+05	.63752E+03	.33000E+04	.17500E+04	.12500E+04	.35000E+04	.17700E+04	.27000E+04
55	.17064E+05	.22814E+03	.21500E+05	.39647E+03	.33000E+04	.17500E+04	.12500E+04	.33750E+04	.17700E+04	.26500E+04
56	.55590E+05	.47583E+03	.49000E+05	.86607E+03	.35500E+04	.20600E+04	.13000E+04	.91000E+04	.18200E+04	.29800E+04

Table K-7. SAMPLE DATA - CORONADO SITE (CONTINUED)

Observation Number	V_{64}	T_{64}	V_{71}	T_{72}	Distance to Bridge access (ft.)	Distance to Orange Ave. (ft.)	Distance to nearest School (ft.)	Lot Area (sq. ft.)	Distance to Navy access (ft.)	Distance to Water (ft.)
57	.30064E+05	.40196E+03	.49000E+05	.81795E+03	.13200E+04	.11700E+04	.11700E+04	.70060E+04	.40250E+04	.30700E+04
58	.27302E+05	.36502E+03	.35500E+05	.67361E+03	.96000E+03	.11200E+04	.14600E+04	.62500E+04	.42000E+04	.28000E+04
59	.23185E+05	.30998E+03	.29000E+05	.58893E+03	.10400E+04	.21000E+04	.18300E+04	.60000E+04	.52800E+04	.19200E+04
60	.22535E+05	.30129E+03	.33500E+05	.55332E+03	.11300E+04	.22200E+04	.18500E+04	.32000E+04	.53200E+04	.19000E+04
61	.36836E+05	.49249E+03	.47500E+05	.81026E+03	.58400E+04	.43200E+04	.60000E+03	.60000E+04	.17300E+04	.34200E+04
62	.39598E+05	.52943E+03	.58000E+05	.94979E+03	.46500E+04	.31800E+04	.96000E+03	.70000E+04	.17300E+04	.34400E+04
63	.21668E+05	.28970E+03	.25000E+05	.49270E+03	.45200E+04	.30600E+04	.11600E+04	.35000E+04	.18700E+04	.35100E+04
64	.24756E+05	.33098E+03	.33500E+05	.55332E+03	.18300E+04	.28000E+04	.27000E+04	.56000E+04	.57300E+04	.16700E+04
65	.34669E+05	.46352E+03	.48000E+05	.81795E+03	.60000E+04	.45300E+04	.10200E+04	.75000E+04	.22100E+04	.39500E+04
66	.34669E+05	.46352E+03	.42000E+05	.76984E+03	.59500E+04	.44700E+04	.10500E+04	.75000E+04	.22400E+04	.40000E+04
67	.34127E+05	.45628E+03	.33000E+05	.77465E+03	.57000E+04	.42000E+04	.10000E+04	.75000E+04	.20700E+04	.39500E+04
68	.34777E+05	.46497E+03	.46000E+05	.75733E+03	.56500E+04	.39000E+04	.70000E+03	.75000E+04	.18750E+04	.36500E+04
69	.34127E+05	.45628E+03	.42500E+05	.76503E+03	.55800E+04	.37000E+04	.98000E+03	.75000E+04	.21400E+04	.39400E+04
70	.37269E+05	.49829E+03	.40000E+05	.86607E+03	.62000E+04	.41000E+04	.15200E+04	.75000E+04	.26800E+04	.44700E+04
71	.35265E+05	.47149E+03	.41000E+05	.89013E+03	.62700E+04	.40000E+04	.18200E+04	.80000E+04	.30200E+04	.48000E+04
72	.41603E+05	.55623E+03	.45500E+05	.91418E+03	.55000E+04	.33200E+04	.14700E+04	.10500E+05	.25600E+04	.42800E+04
73	.33477E+05	.44759E+03	.50000E+05	.79390E+03	.49000E+04	.28000E+04	.14000E+04	.70000E+04	.23000E+04	.40300E+04
74	.40953E+05	.54754E+03	.65000E+05	.85067E+03	.49000E+04	.28000E+04	.14000E+04	.70000E+04	.23000E+04	.39700E+04
75	.54549E+05	.72932E+03	.90000E+05	.12625E+04	.48200E+04	.28200E+04	.12500E+04	.10500E+05	.21400E+04	.38200E+04
76	.32773E+05	.43817E+03	.45500E+05	.90168E+03	.45500E+04	.25800E+04	.12800E+04	.60000E+04	.20500E+04	.37000E+04
77	.40302E+05	.53884E+03	.50000E+05	.98636E+03	.35400E+04	.14300E+04	.85000E+03	.70000E+04	.26500E+04	.38700E+04
78	.34127E+05	.45628E+03	.38000E+05	.74578E+03	.34700E+04	.13000E+04	.72000E+03	.70000E+04	.28300E+04	.39400E+04
79	.43715E+05	.58447E+03	.50000E+05	.93824E+03	.36300E+04	.13000E+04	.83000E+03	.70000E+04	.30000E+04	.38400E+04
80	.11592E+05	.15499E+03	.17500E+05	.33680E+03	.32600E+04	.87000E+03	.58000E+03	.20880E+04	.32500E+04	.35000E+04
81	.23239E+05	.31070E+03	.27000E+05	.57738E+03	.32600E+04	.87000E+03	.58000E+03	.70000E+04	.32500E+04	.35000E+04
82	.89435E+05	.11957E+04	.12700E+06	.21171E+04	.28700E+04	.30000E+03	.53000E+03	.70000E+04	.37200E+04	.29800E+04
83	.10942E+05	.14630E+03	.18000E+05	.31275E+03	.30200E+04	.57000E+03	.45000E+03	.15000E+04	.34700E+04	.32200E+04
84	.25947E+05	.34692E+03	.40000E+05	.72172E+03	.22200E+04	.52000E+03	.10000E+04	.56000E+04	.42700E+04	.24800E+04
85	.30173E+05	.40341E+03	.45000E+05	.73616E+03	.22500E+04	.10700E+04	.16500E+04	.63000E+04	.49000E+04	.19400E+04
86	.27302E+05	.36502E+03	.40000E+05	.76984E+03	.18300E+04	.15800E+04	.20300E+04	.41600E+04	.51000E+04	.19800E+04
87	.27302E+05	.36502E+03	.35000E+05	.67361E+03	.27500E+04	.22300E+04	.28500E+04	.60000E+04	.61000E+04	.97000E+03
88	.35481E+05	.47439E+03	.46000E+05	.89013E+03	.29200E+04	.21900E+04	.29200E+04	.60000E+04	.62000E+04	.80000E+03
89	.15709E+05	.21003E+03	.25500E+05	.50521E+03	.23500E+04	.28200E+04	.28700E+04	.56000E+04	.64000E+04	.14500E+04
90	.15655E+05	.20931E+03	.24000E+05	.40898E+03	.27200E+04	.31500E+04	.31800E+04	.26570E+04	.68000E+04	.12500E+04
91	.43661E+05	.58375E+03	.78000E+05	.12029E+04	.31200E+04	.28300E+04	.34500E+04	.78000E+04	.67600E+04	.70000E+03
92	.53953E+05	.72136E+03	.86500E+05	.11788E+04	.34200E+04	.30300E+04	.37200E+04	.78000E+04	.70600E+04	.65000E+03
93	.21560E+05	.28825E+03	.29000E+05	.50521E+03	.27400E+04	.68000E+03	.14600E+04	.70000E+04	.47300E+04	.19500E+04
94	.22535E+05	.30129E+03	.33000E+05	.45709E+03	.34300E+04	.87000E+03	.21500E+04	.30000E+04	.54000E+04	.14000E+04
95	.36186E+05	.48380E+03	.54000E+05	.81795E+03	.29500E+04	.12700E+04	.21300E+04	.63000E+04	.54500E+04	.12600E+04
96	.38244E+05	.51132E+03	.63500E+05	.10104E+04	.32700E+04	.14500E+04	.25200E+04	.50000E+04	.58000E+04	.91000E+03
97	.15904E+06	.21264E+04	.22300E+06	.38492E+04	.42300E+04	.25000E+03	.31800E+04	.65000E+04	.61700E+04	.59000E+03
98	.34777E+05	.46497E+03	.47000E+05	.80545E+03	.46300E+04	.31800E+04	.23800E+04	.70000E+04	.14800E+04	.33000E+03
99	.23889E+05	.31940E+03	.32000E+05	.63704E+03	.26800E+04	.17200E+04	.26000E+04	.40000E+04	.31300E+04	.47000E+03
100	.43661E+05	.58375E+03	.65000E+05	.90168E+03	.40700E+04	.25400E+04	.18600E+04	.70000E+04	.10300E+04	.11200E+04
101	.23997E+05	.32084E+03	.32000E+05	.46864E+03	.34600E+04	.19500E+04	.22300E+04	.56000E+04	.15100E+04	.13000E+04
102	.24702E+05	.33026E+03	.34000E+05	.54081E+03	.23300E+04	.11400E+04	.22700E+04	.63000E+04	.28400E+04	.11100E+04
103	.55958E+05	.74815E+03	.75000E+05	.14434E+04	.21300E+04	.10700E+04	.22800E+04	.70000E+04	.30300E+04	.11900E+04
104	.53141E+05	.71049E+03	.82500E+05	.14309E+04	.20100E+04	.10700E+04	.21800E+04	.10500E+05	.32000E+04	.11200E+04
105	.14301E+05	.19120E+03	.17500E+05	.33680E+03	.16300E+04	.11000E+04	.16900E+04	.33000E+04	.36600E+04	.12500E+04
106	.45719E+05	.61127E+03	.50000E+05	.96230E+03	.15200E+04	.11900E+04	.15000E+04	.70000E+04	.38400E+04	.12600E+04
107	.56608E+05	.75684E+03	.83000E+05	.13232E+04	.12300E+04	.86000E+03	.14600E+04	.70000E+04	.38000E+04	.16600E+04
108	.20476E+05	.27377E+03	.34500E+05	.50521E+03	.87000E+03	.15200E+04	.72000E+03	.30000E+04	.46200E+04	.14700E+04
109	.24593E+05	.32881E+03	.32500E+05	.61299E+03	.36300E+04	.20700E+04	.18200E+04	.70000E+04	.11700E+04	.16400E+04
110	.15709E+05	.21003E+03	.22500E+05	.45709E+03	.71000E+03	.12100E+04	.94000E+03	.30000E+04	.43400E+04	.17800E+04
111	.30714E+05	.41065E+03	.48000E+05	.67361E+03	.54000E+03	.20000E+04	.40000E+03	.40000E+04	.53800E+04	.15600E+04
112	.17768E+05	.23755E+03	.26500E+05	.36086E+03	.43700E+04	.27600E+04	.88000E+03	.35000E+04	.55000E+03	.20800E+04
113	.19122E+05	.25566E+03	.25000E+05	.52926E+03	.44100E+04	.28200E+04	.92000E+03	.50000E+04	.45000E+03	.19500E+04
Mean:	31,055	415	41,704	736	3140	1986	1631	6088	2950	2027
Standard Deviation:	16,899	226	25,120	412	1443	1008	754	2098	1645	1102

Table K-8. SAMPLE DATA - CLACKAMAS COUNTY URBAN SITE

Observation Number	V_{63}	V_{70}	T_{63}	T_{70}	Distance to Water (ft.)	Distance to Park (ft.)	Distance to nearest School (ft.)	Distance to Shopping Center (ft.)	Distance to Highway 99E (ft.)	Distance to Portland (ft.)	Lot Area (sq. ft.)
1	.33350E+05	.47425E+05	.76147E+03	.79200E+03	0.	.76800E+04	.20800E+04	.61000E+04	.42800E+04	.45600E+04	.39600E+05
2	.20415E+05	.22500E+05	.46626E+03	.57800E+03	.17000E+04	.70800E+04	.72000E+03	.48000E+04	.23200E+04	.32000E+04	.12000E+05
3	.10857E+05	.11018E+05	.24833E+03	.20600E+03	.18800E+04	.69200E+04	.72000E+03	.46000E+04	.20400E+04	.30000E+04	.16000E+05
4	.16779E+05	.20599E+05	.38263E+03	.45100E+03	.19600E+04	.70400E+04	.72000E+03	.46000E+04	.20400E+04	.30000E+04	.12000E+05
5	.18078E+05	.24000E+05	.41304E+03	.51800E+03	.84000E+03	.68000E+04	.20400E+04	.56800E+04	.41600E+04	.50000E+04	.74250E+04
6	.19584E+05	.27004E+05	.44725E+03	.52500E+03	.11200E+04	.66000E+04	.17200E+04	.53200E+04	.38400E+04	.48000E+04	.14700E+05
7	.16311E+05	.19062E+05	.37250E+03	.41000E+03	.13600E+04	.65200E+04	.15200E+04	.52000E+04	.36400E+04	.46800E+04	.14175E+05
8	.12571E+05	.10200E+05	.28634E+03	.27100E+03	.18400E+04	.65600E+04	.40000E+03	.46000E+04	.26000E+04	.37200E+04	.18000E+05
9	.28363E+05	.50302E+05	.64744E+03	.11970E+04	.28000E+04	.64000E+04	.70000E+03	.37200E+04	.14000E+04	.31200E+04	.14805E+06
10	.18909E+05	.25500E+05	.43205E+03	.57300E+03	.28800E+04	.60800E+04	.60000E+03	.35600E+04	.16000E+04	.35600E+04	.58300E+05
11	.12571E+05	.15620E+05	.28634E+03	.32200E+03	.31800E+04	.61200E+04	.10000E+04	.33600E+04	.12000E+04	.34000E+04	.49950E+05
12	.12760E+05	.14296E+05	.32562E+03	.33300E+03	.24000E+04	.50400E+04	.10800E+04	.38400E+04	.30000E+04	.52400E+04	.11700E+05
13	.23428E+05	.31770E+05	.53467E+03	.61900E+03	.76000E+03	.64000E+04	.24800E+04	.56800E+04	.46000E+04	.57200E+04	.13750E+05
14	.10026E+05	.11750E+05	.22933E+03	.27000E+03	.10800E+04	.61600E+04	.22000E+04	.53200E+04	.42800E+04	.55200E+04	.23200E+05
15	.10009E+05	.13767E+05	.22806E+03	.31600E+03	.10800E+04	.60800E+04	.22000E+04	.52800E+04	.42800E+04	.55600E+04	.14025E+05
16	.58700E+04	.85000E+04	.13430E+03	.22300E+03	.17200E+04	.58400E+04	.16000E+04	.47200E+04	.36000E+04	.51200E+04	.91000E+04
17	.12571E+05	.13250E+05	.28634E+03	.30400E+03	.19200E+04	.59200E+04	.14000E+04	.46000E+04	.34000E+04	.48800E+04	.65000E+04
18	.19116E+05	.19591E+05	.43585E+03	.32200E+03	.12400E+04	.57200E+04	.19600E+04	.50400E+04	.41200E+04	.56800E+04	.26250E+05
19	.17143E+05	.26000E+05	.39150E+03	.58500E+03	.14000E+04	.56800E+04	.18800E+04	.49200E+04	.39600E+04	.56000E+04	.26250E+05
20	.18285E+05	.23721E+05	.41684E+03	.64300E+03	.38000E+04	.47200E+04	.13600E+04	.25600E+04	.16000E+04	.48000E+04	.74750E+04
21	.36155E+05	.37126E+05	.82482E+03	.72600E+03	0.	.59600E+04	.28000E+04	.60200E+04	.53200E+04	.68400E+04	.16200E+05
22	.89868E+04	.11000E+05	.20525E+03	.29500E+03	.92000E+03	.55600E+04	.20400E+04	.52400E+04	.44800E+04	.62000E+04	.91000E+04
23	.25350E+05	.24621E+05	.57902E+03	.68100E+03	.40000E+03	.56000E+04	.24400E+04	.56800E+04	.50000E+04	.67600E+04	.13050E+05
24	.39480E+04	.63540E+04	.89957E+02	.18100E+03	.16000E+04	.52400E+04	.14400E+04	.45600E+04	.38000E+04	.57600E+04	.76500E+04
25	.15732E+05	.17550E+05	.49164E+03	.37500E+03	.28800E+04	.47200E+04	.76000E+03	.33200E+04	.25200E+04	.52000E+04	.80000E+04
26	.12104E+05	.13892E+05	.[illegible]7621E+03	.28100E+03	.30800E+04	.44800E+04	.60000E+03	.31200E+04	.23800E+04	.53200E+04	.12500E+05
27	.85193E+04	.11736E+05	.19385E+03	.22900E+03	.33200E+04	.48000E+04	.10800E+04	.30000E+04	.20800E+04	.48800E+04	.10000E+05
28	.11896E+05	.17000E+05	.27114E+03	.34000E+03	.34400E+04	.48000E+04	.11200E+04	.29200E+04	.20000E+04	.48800E+04	.85000E+04
29	.24987E+05	.31617E+05	.57015E+03	.57800E+03	0.	.54000E+04	.27200E+04	.59200E+04	.54000E+04	.74000E+04	.19125E+05
30	.18181E+05	.16287E+05	.41431E+03	.38400E+03	.20000E+03	.52800E+04	.27200E+04	.59200E+04	.54000E+04	.75200E+04	.72000E+04
31	.10909E+05	.10000E+05	.24833E+03	.26700E+03	.40000E+03	.52400E+04	.24000E+04	.56000E+04	.50800E+04	.72000E+04	.32300E+05
32	.21194E+05	.20950E+05	.48399E+03	.46600E+03	.68000E+03	.52800E+04	.21200E+04	.53600E+04	.47200E+04	.66800E+04	.26100E+05
33	.57142E+04	.10778E+05	.13050E+03	.22500E+03	.96000E+03	.48000E+04	.18400E+04	.50800E+04	.45200E+04	.68800E+04	.20350E+05
34	.70648E+04	.91010E+04	.16091E+03	.12700E+03	.13600E+04	.45600E+04	.14400E+04	.46800E+04	.41200E+04	.66800E+04	.23100E+05
35	.37142E+05	.37065E+05	.84762E+03	.84700E+03	0.	.51200E+04	.32800E+04	.63600E+04	.58800E+04	.84000E+04	.14250E+05
36	.92466E+04	.88620E+04	.21159E+03	.21000E+03	.10800E+04	.45600E+04	.18800E+04	.50400E+04	.45200E+04	.71800E+04	.68250E+04
37	.22129E+05	.20800E+05	.50553E+03	.51900E+03	.13600E+04	.42400E+04	.16800E+04	.48400E+04	.43200E+04	.72000E+04	.34850E+05
38	.14233E+05	.17500E+05	.32435E+03	.36300E+03	.15200E+04	.41600E+04	.15200E+04	.46400E+04	.41600E+04	.70800E+04	.12800E+05
39	.23013E+05	.21000E+05	.52454E+03	.55200E+03	.15200E+04	.41200E+04	.15200E+04	.46400E+04	.41600E+04	.71200E+04	.10400E+05
40	.78440E+04	.11976E+05	.17865E+03	.24000E+03	.16400E+04	.41600E+04	.12800E+04	.44400E+04	.39600E+04	.68400E+04	.14250E+05
41	.93505E+04	.11497E+05	.21286E+03	.24000E+03	.16800E+04	.40800E+04	.13200E+04	.44400E+04	.39600E+04	.69600E+04	.11875E+05
42	.10805E+05	.16096E+05	.24707E+03	.28200E+03	.28000E+04	.35800E+04	.48000E+03	.32800E+04	.28400E+04	.64400E+04	.55000E+04
43	.54544E+05	.57486E+05	.12442E+04	.13070E+04	.30800E+04	.34800E+04	.48000E+03	.29200E+04	.24800E+04	.63200E+04	.18000E+05
44	.11324E+05	.10060E+05	.25847E+03	.29300E+03	.21200E+04	.36400E+04	.11600E+04	.40800E+04	.36400E+04	.70000E+04	.34000E+05
45	.18233E+05	.16239E+05	.41558E+03	.43200E+03	.24800E+04	.31200E+04	.11200E+04	.38000E+04	.34000E+04	.70400E+04	.90000E+04
46	.69609E+04	.95000E+04	.15837E+03	.21500E+03	.24000E+04	.38000E+04	.56000E+03	.36800E+04	.31600E+04	.64400E+04	.58500E+04
47	.17922E+05	.17367E+05	.40924E+03	.39900E+03	.26400E+04	.30000E+04	.13600E+04	.38000E+04	.34000E+04	.72800E+04	.12350E+05
48	.20039E+05	.23473E+05	.51187E+03	.53800E+03	.30800E+04	.30400E+04	.96000E+03	.28000E+04	.27600E+04	.64800E+04	.12000E+05
49	.10701E+05	.12178E+05	.24453E+03	.32100E+03	.32800E+04	.27200E+04	.12400E+04	.30800E+04	.26800E+04	.66800E+04	.72000E+04
50	.28675E+05	.31617E+05	.65377E+03	.81700E+03	0.	.46400E+04	.42800E+04	.56000E+03	.64800E+04	.99200E+04	.21375E+05
51	.22857E+05	.25151E+05	.52074E+03	.50700E+03	.24000E+03	.42800E+04	.41600E+04	.67200E+04	.65200E+04	.99200E+04	.18900E+05
52	.18337E+05	.17897E+05	.41811E+03	.43300E+03	.52000E+03	.42800E+04	.39200E+04	.65600E+04	.61600E+04	.96000E+04	.22400E+05
53	.19168E+05	.19449E+05	.43711E+03	.42300E+03	.72000E+03	.38800E+04	.36800E+04	.62000E+04	.58000E+04	.80400E+04	.22800E+05
54	.96621E+04	.10500E+05	.22046E+03	.28200E+03	.21200E+04	.31600E+04	.20400E+04	.45600E+04	.41600E+04	.79600E+04	.20250E+05
55	.12623E+05	.17367E+05	.28761E+03	.39200E+03	.22000E+04	.30000E+04	.22000E+04	.46000E+04	.42400E+04	.81600E+04	.20250E+05
56	.22805E+05	.33900E+05	.52074E+03	.58600E+03	.18000E+04	.25200E+04	.26400E+04	.46800E+04	.43200E+04	.86000E+04	.76875E+05

Table K-8. SAMPLE DATA - CLACKAMAS COUNTY URBAN SITE (CONTINUED)

Observation Number	V_{63}	V_{70}	T_{63}	T_{70}	Distance to Water (ft.)	Distance to Park (ft.)	Distance to nearest School (ft.)	Distance to Shopping Center (ft.)	Distance to Highway 99E (ft.)	Distance to Portland (ft.)	Lot Area (sq. ft.)
57	.17818E+05	.19162E+05	.40671E+03	.48600E+03	.31600E+04	.25200E+04	.15200E+04	.32800E+04	.29200E+04	.73200E+04	.23925E+05
58	.43843E+05	.47655E+05	.88817E+03	.93000E+03	0.	.32400E+04	.30800E+04	.62800E+04	.58400E+04	.10240E+05	.57500E+05
59	.24519E+05	.29652E+05	.49666E+03	.68400E+03	0.	.32000E+04	.30000E+04	.62800E+04	.58000E+04	.10240E+05	.57500E+05
60	.24363E+05	.21180E+05	.49286E+03	.75800E+03	.60000E+03	.28800E+04	.29200E+04	.58400E+04	.54000E+04	.98000E+04	.13200E+05
61	.32882E+05	.21000E+05	.66644E+03	.85700E+03	.13600E+04	.27600E+04	.31200E+04	.52000E+04	.48000E+04	.90400E+04	.11200E+05
62	.15688E+05	.17676E+05	.31802E+03	.38200E+03	.19200E+04	.18400E+04	.25200E+04	.41600E+04	.37200E+04	.85200E+04	.24000E+05
63	.14389E+05	.14850E+05	.29141E+03	.34400E+03	.20000E+04	.64000E+03	.16800E+04	.38800E+04	.32000E+04	.88800E+04	.14400E+05
64	.18961E+05	.27219E+05	.38390E+03	.48200E+03	.18400E+04	.44000E+03	.13200E+04	.43200E+04	.33600E+04	.92000E+04	.12600E+05
65	.23272E+05	.27004E+05	.47132E+03	.58400E+03	.24000E+04	.52000E+03	.17600E+04	.35200E+04	.25200E+04	.90400E+04	.20900E+05
66	.12727E+05	.16191E+05	.25720E+03	.33500E+03	.26800E+04	.88000E+03	.20800E+04	.32400E+04	.21600E+04	.88800E+04	.18000E+05
67	.15532E+05	.21709E+05	.31422E+03	.44800E+03	.26800E+04	.88000E+03	.20800E+04	.32800E+04	.21600E+04	.89600E+04	.25500E+05
68	.12415E+05	.14773E+05	.25087E+03	.29500E+03	.26800E+04	.92000E+03	.20800E+04	.33200E+04	.21600E+04	.90000E+04	.25500E+05
69	.10649E+05	.13237E+05	.21539E+03	.28900E+03	.30400E+04	.12800E+04	.24000E+04	.29600E+04	.17600E+04	.87600E+04	.35650E+05
70	.45817E+05	.61241E+05	.92744E+03	.11100E+04	0.	.19200E+04	.14400E+04	.57200E+04	.50000E+04	.10480E+05	.41000E+05
71	.23740E+05	.25945E+05	.49540E+03	.54600E+03	.40000E+03	.16800E+04	.96000E+03	.56400E+04	.47200E+04	.10680E+05	.99000E+04
72	.94430E+04	.23952E+05	.21539E+03	.38100E+03	.92000E+03	.92000E+03	.40000E+03	.50000E+04	.38400E+04	.10280E+05	.20000E+05
73	.19428E+05	.19641E+05	.44345E+03	.50600E+03	.19600E+04	.64000E+03	.13200E+04	.40800E+04	.26800E+04	.96800E+04	.14875E+05
74	.18441E+05	.22946E+05	.37376E+03	.42400E+03	.25200E+04	.12400E+04	.19600E+04	.37200E+04	.20400E+04	.94800E+04	.15000E+05
75	.30805E+05	.34012E+05	.62336E+03	.85100E+03	.12000E+03	.17600E+04	.60000E+03	.58000E+04	.45600E+04	.10960E+05	.24000E+05
76	.16727E+05	.37844E+05	.33829E+03	.43100E+03	.11600E+04	.10400E+04	.60000E+03	.48800E+04	.34000E+04	.10400E+05	.25500E+05
77	.19792E+05	.30000E+05	.40037E+03	.55000E+03	.13600E+04	.13600E+04	.10400E+04	.48800E+04	.30800E+04	.10440E+05	.87750E+05
78	.12623E+05	.13978E+05	.25593E+03	.30700E+03	.32000E+04	.23200E+04	.28400E+04	.39200E+04	.12400E+04	.98000E+04	.75000E+04
79	.20259E+05	.21000E+05	.41051E+03	.45200E+03	.12800E+04	.22400E+04	.16400E+04	.55200E+04	.30800E+04	.11280E+05	.12000E+05
80	.12363E+05	.13413E+05	.25087E+03	.32900E+03	.13600E+04	.22400E+04	.17200E+04	.54800E+04	.29200E+04	.11120E+05	.12825E+05
81	.10857E+05	.11497E+05	.22046E+03	.31400E+03	.15600E+04	.20400E+04	.16800E+04	.52000E+04	.28000E+04	.10970E+05	.21250E+05
82	.14441E+05	.13892E+05	.29268E+03	.34800E+03	.16400E+04	.25200E+04	.21600E+04	.54400E+04	.26000E+04	.11200E+05	.11400E+05
83	.10597E+05	.12500E+05	.21412E+03	.28200E+03	.25200E+04	.29200E+04	.28800E+04	.50800E+04	.16400E+04	.92000E+03	.64000E+05
84	.15844E+05	.13413E+05	.32055E+03	.40700E+03	.33600E+04	.36000E+04	.38800E+04	.48400E+04	.52000E+03	.10680E+05	.14500E+05
85	.13454E+05	.12800E+05	.27240E+03	.31700E+03	.32800E+04	.27200E+04	.30800E+04	.42400E+04	.10800E+04	.10240E+05	.30000E+05
86	.19740E+05	.23473E+05	.39910E+03	.54600E+03	.44000E+03	.29200E+04	.20000E+04	.64000E+04	.37200E+04	.12080E+05	.21000E+05
87	.25870E+05	.27004E+05	.52327E+03	.56400E+03	.19200E+04	.28000E+04	.24800E+04	.54400E+04	.22400E+04	.11280E+05	.11000E+05
88	.23064E+05	.23473E+05	.47512E+03	.57000E+03	.10800E+04	.37200E+04	.31200E+04	.64800E+04	.25600E+04	.12320E+05	.81000E+04
89	.16987E+05	.17950E+05	.34336E+03	.40100E+03	.28400E+04	.34800E+04	.35600E+04	.51200E+04	.10000E+04	.11120E+05	.24225E+05
90	.12675E+05	.13500E+05	.25720E+03	.32100E+03	.29200E+04	.35200E+04	.36400E+04	.51200E+04	.88000E+03	.11120E+05	.24225E+05
91	.30181E+05	.33533E+05	.61069E+03	.92200E+03	0.	.41200E+04	.32800E+04	.72800E+04	.34000E+04	.13080E+05	.46600E+05
92	.27324E+05	.25000E+05	.56255E+03	.74800E+03	0.	.42400E+04	.34000E+04	.73200E+04	.33600E+04	.13120E+05	.28900E+05
93	.36467E+05	.40771E+05	.73866E+03	.80400E+03	.32000E+03	.48000E+04	.40800E+04	.75600E+04	.28400E+04	.13480E+05	.25000E+05
94	.21818E+04	.40000E+04	.49413E+02	.16200E+03	.40000E+03	.49200E+04	.42400E+04	.76000E+04	.26800E+04	.13520E+05	.18400E+05
95	.15013E+05	.18000E+05	.30915E+03	.40700E+03	.64000E+03	.44400E+04	.38000E+04	.71200E+04	.26000E+04	.13000E+05	.67500E+04
96	.14337E+05	.14371E+05	.29521E+03	.39700E+03	.64000E+03	.46000E+04	.40000E+04	.72800E+04	.25600E+04	.13200E+05	.10800E+05
97	.29350E+05	.31138E+05	.60436E+03	.65900E+03	.84000E+03	.48400E+04	.42400E+04	.72800E+04	.21600E+04	.13200E+05	.43750E+05
98	.96102E+04	.19697E+05	.21539E+03	.35500E+03	.84000E+03	.49600E+04	.44000E+04	.73200E+04	.21200E+04	.13280E+05	.43750E+05
Mean:	18,162	21,144	396	470	1596	2941	2048	4877	3417	8013	22,630
Standard Deviation:	9168	10,755	197	226	1056	1788	1071	1304	1353	2872	20,071

Table K-9. SAMPLE DATA - CLACKAMAS COUNTY RURAL SITE

Observation Number	V_{60}	T_{60}	V_{70}	T_{70}	Distance to Water (ft.)	Distance to nearest Boat Ramp (miles)	Distance to nearest Bridge (miles)	Distance to Portland (miles)	Distance to nearest Town (miles)	Waterfront footage	Lot Area (acres)
1	.11001E+05	.20429E+03	.21174E+05	.48422E+03	.25000E+04	.12000E+01	.46000E+01	.18500E+02	.46000E+01	0.	.13100E+02
2	.78168E+04	.14516E+03	.24350E+05	.44382E+03	.25000E+04	.11000E+01	.47000E+01	.18600E+02	.47000E+01	0.	.13000E+02
3	.72377E+04	.13441E+03	.71392E+04	.24182E+03	.50000E+02	.80000E+00	.48000E+01	.19400E+02	.60000E+01	.10000E+03	.60000E+00
4	.90469E+04	.16801E+03	.13174E+05	.24182E+03	.50000E+02	.90000E+00	.49000E+01	.19500E+02	.60000E+01	.15000E+03	.80000E+00
5	.11580E+04	.15615E+02	.26772E+04	.10857E+03	.12000E+04	.20000E+01	.53000E+01	.20600E+02	.20000E+01	0.	.10000E+01
6	.27497E+04	.51077E+02	.14267E+05	.33998E+03	.39000E+04	.80000E+00	.44000E+01	.18200E+02	.51000E+01	0.	.85000E+01
7	.17587E+05	.32661E+03	.36254E+05	.85350E+03	.17500E+04	.40000E+00	.39000E+01	.18200E+02	.56000E+01	0.	.26600E+02
8	.73819E+04	.99547E+02	.10060E+05	.21714E+03	.50000E+02	.30000E+00	.35000E+01	.18700E+02	.24000E+01	.15000E+03	.70000E+00
9	.57902E+04	.78076E+02	.79402E+04	.19646E+03	.50000E+02	.60000E+00	.32000E+01	.18700E+02	.23000E+01	.10000E+03	.50000E+00
10	.54286E+04	.72705E+02	.13386E+05	.20517E+03	.50000E+02	.19000E+01	.22000E+01	.17700E+02	.32000E+01	.15000E+03	.10000E+01
11	.54286E+04	.72705E+02	.95283E+04	.25583E+03	.50000E+02	.21000E+01	.19000E+01	.17700E+02	.33000E+01	.15000E+03	.10000E+01
12	.11073E+05	.21506E+03	.18204E+05	.60240E+03	.50000E+02	.16000E+01	.13000E+01	.17700E+02	.79000E+01	.10000E+03	.14000E+01
13	.11797E+05	.24598E+03	.16732E+05	.42168E+03	.50000E+02	.15000E+01	.11000E+01	.17700E+02	.80000E+01	.15000E+03	.80000E+00
14	.14245E+05	.24598E+03	.11155E+05	.49698E+03	.50000E+02	.13000E+01	.10000E+01	.17700E+02	.81000E+01	.15000E+03	.11000E+01
15	.27379E+04	.53409E+02	.38324E+04	.10542E+03	.11500E+04	.50000E+00	.40000E+00	.17900E+02	.92000E+01	0.	.50000E+00
16	.23161E+04	.31021E+02	.65000E+04	.57750E+02	.10000E+04	.40000E+00	.30000E+00	.18600E+02	.96000E+01	0.	.24000E+01
17	.11797E+05	.15801E+03	.22310E+05	.46860E+03	.46000E+04	.10000E+01	.90000E+00	.19200E+02	.10200E+02	0.	.35700E+02
18	.94805E+04	.12699E+03	.27999E+05	.54594E+03	.50000E+02	.10000E+00	.40000E+00	.18400E+02	.97000E+01	.45000E+03	.31000E+01
19	.27497E+04	.36837E+02	.11500E+05	.12412E+03	.50000E+02	.20000E+00	.60000E+00	.18400E+02	.98000E+01	.10000E+03	.90000E+00
20	.34741E+04	.46531E+02	.11500E+05	.12412E+03	.50000E+02	.30000E+00	.70000E+00	.18400E+02	.98000E+01	.10000E+03	.90000E+00
21	.26776E+04	.35868E+02	.10539E+05	.15071E+03	.50000E+02	.30000E+00	.70000E+00	.18400E+02	.99000E+01	.10000E+03	.70000E+00
22	.12449E+05	.24177E+03	.23872E+05	.63252E+03	.50000E+02	.60000E+00	.10000E+01	.18400E+02	.10100E+02	.30000E+03	.15000E+01
23	.14692E+05	.27285E+03	.22000E+05	.69702E+03	.61000E+04	.20000E+01	.24000E+01	.18400E+02	.11200E+02	0.	.20000E+02
24	.12301E+04	.16480E+02	.55775E+04	.10874E+03	.50000E+02	.10000E+01	.21000E+01	.19500E+02	.11300E+02	.10000E+03	.50000F+00
25	.24602E+04	.32960E+02	.12440E+05	.25558E+03	.50000E+02	.90000E+00	.22000E+01	.19600E+02	.11400E+02	.50000E+02	.30000E+01
26	.62238E+04	.83368E+02	.38113E+05	.78303E+03	.50000E+02	.20000E+00	.29000E+01	.20000E+02	.12200E+02	.45000E+03	.12100E+02
27	.16650E+04	.19951E+02	.25000E+04	.49430E+02	.16000E+04	.46000E+01	.41000E+01	.21900E+02	.62000E+01	0.	.29000E+01
28	.12955E+05	.27875E+03	.80000E+05	.26372E+03	.50000E+02	.30000E+01	.13400E+02	.33600E+02	.92000E+01	.10500E+04	.30000E+02
29	.50003E+04	.11332E+03	.66930E+04	.13984E+03	.12000E+04	.18000E+01	.14000E+02	.33800E+02	.10500E+02	0.	.20000E+02
30	.36497E+04	.82713E+02	.33465E+04	.98990E+02	.70000E+03	.18000E+01	.14000E+02	.33800E+02	.10500E+02	0.	.10000E+02
31	.65998E+04	.14958E+03	.32000E+05	.12356E+03	.13000E+04	.30000E+00	.12800E+02	.35200E+02	.11400E+02	0.	.17400E+02
32	.23331E+04	.27287E+02	.22310E+04	.49810E+02	.13000E+04	.12000E+01	.40000E+01	.21400E+02	.13300E+02	0.	.19000E+01
33	.55714E+04	.65762E+02	.10481E+05	.24605E+03	.16500E+04	.10000E+01	.37000E+01	.21100E+02	.13000E+02	0.	.66000E+01
34	.19742E+04	.23082E+02	.49821E+04	.11322E+03	.38000E+03	.10000E+01	.38000E+01	.21100E+02	.13100E+02	0.	.33000E+01
Mean:	6758	117	16,013	301	992	1.14	3.85	20.8	8.26	115	7.16
Standard Deviation:	4513	89.6	14,847	224	1459	0.99	3.91	5.07	3.36	203	9.54

Table K-10. SAMPLE DATA - CHARLESTON SITE

Observation Number	V_{60}	T_{60}	V_{70}	T_{70}	Distance to Water (ft.)	Distance to nearest School (ft.)	Distance to Mac Corkle Ave. (ft.)	Distance to Bridge access (ft.)	Waterfront Dummy Variable	Lot Area (sq. ft.)
1	.30075E+05	.19019E+03	.47022E+05	.37025E+03	.20000E+02	.16900E+04	.14600E+04	.76000E+04	.10000E+01	.24885E+05
2	.18646E+05	.56711E+02	.19092E+05	.15033E+03	.85000E+03	.38700E+04	.57000E+03	.10100E+05	0.	.60000E+04
3	.34285E+05	.10374E+03	.30641E+05	.24127E+03	.10000E+04	.51000E+03	.75000E+03	.65200E+04	0.	.90000E+04
4	.25864E+05	.95095E+02	.25456E+05	.20044E+03	.90000E+03	.68000E+03	.54000E+03	.14000E+04	0.	.60000E+04
5	.24060E+05	.86450E+02	.22745E+05	.17909E+03	.72000E+03	.86000E+03	.74000E+03	.16400E+04	0.	.60000E+04
6	.27669E+05	.95095E+02	.26163E+05	.20601E+03	.70000E+03	.53000E+03	.74000E+03	.13600E+04	0.	.60000E+04
7	.63759E+05	.25935E+03	.55389E+05	.43614E+03	.57000E+03	.86000E+03	.12000E+04	.58300E+04	0.	.12000E+05
8	.22255E+05	.62244E+02	.20859E+05	.16425E+03	.70000E+03	.33200E+04	.73000E+03	.94200E+04	0.	.60000E+04
9	.30676E+05	.86450E+02	.29462E+05	.23199E+03	.45000E+03	.19100E+04	.10500E+04	.27400E+04	0.	.60000E+04
10	.19248E+05	.95095E+02	.17913E+05	.14105E+03	.42000E+03	.11600E+04	.10300E+04	.19600E+04	0.	.60000E+04
11	.33684E+05	.14697E+03	.29462E+05	.23199E+03	.89000E+03	.43000E+03	.54000E+03	.12400E+04	0.	.60000E+04
12	.10225E+05	.86450E+02	.19445E+05	.15311E+03	.98000E+03	.57000E+03	.10400E+04	.10800E+04	0.	.60000E+04
13	.23458E+05	.69160E+02	.19563E+05	.15404E+03	.12400E+04	.94000E+03	.55000E+03	.47900E+04	0.	.60000E+04
14	.60150E+05	.25935E+03	.59279E+05	.46676E+03	.20000E+02	.11200E+04	.15400E+04	.63500E+04	.10000E+01	.43000E+05
15	.22135E+05	.77805E+02	.25338E+05	.19951E+03	.12600E+04	.16500E+04	.24000E+03	.22300E+04	0.	.60000E+04
16	.22857E+05	.10374E+03	.25102E+05	.19765E+03	.64000E+03	.30000E+03	.73000E+03	.76000E+03	0.	.60000E+04
17	.22857E+05	.55328E+02	.20388E+05	.16054E+03	.50000E+03	.39900E+04	.88000E+03	.10250E+05	0.	.45000E+04
18	.23940E+05	.77805E+02	.20859E+05	.16425E+03	.83000E+03	.21400E+04	.73000E+03	.81800E+04	0.	.72000E+04
19	.34285E+05	.15561E+03	.36180E+05	.28488E+03	.17900E+04	.21000E+03	.23000E+03	.38000E+03	0.	.80000E+04
20	.27669E+05	.84721E+02	.24395E+05	.19209E+03	.30000E+03	.53000E+03	.10600E+04	.13200E+04	0.	.60000E+04
21	.19970E+05	.77805E+02	.17560E+05	.13826E+03	.12400E+04	.10200E+04	.41000E+03	.71700E+04	0.	.60000E+04
22	.24060E+05	.86450E+02	.23452E+05	.18466E+03	.24000E+03	.36600E+04	.12100E+04	.97300E+04	0.	.60000E+04
23	.25864E+05	.82992E+02	.21095E+05	.16610E+03	.30000E+03	.52000E+03	.10600E+04	.12600E+04	0.	.60000E+04
24	.12030E+05	.41496E+02	.14849E+05	.11692E+03	.96000E+03	.40600E+04	.40000E+03	.10070E+05	0.	.48000E+04
25	.25263E+05	.77805E+02	.17795E+05	.14012E+03	.13900E+04	.10400E+04	.24000E+03	.62000E+03	0.	.60000E+04
26	.30676E+05	.10374E+03	.26398E+05	.20786E+03	.11800E+04	.31100E+04	.18000E+03	.26000E+04	0.	.60000E+04
27	.21052E+05	.69160E+02	.19327E+05	.15218E+03	.66000E+03	.23200E+04	.87000E+03	.83500E+04	0.	.60000E+04
28	.21052E+05	.69160E+02	.20034E+05	.15775E+03	.11600E+04	.13900E+04	.23000E+03	.20200E+04	0.	.60000E+04
29	.16240E+05	.36309E+02	.15320E+05	.12063E+03	.11200E+04	.39800E+04	.25000E+03	.10100E+05	0.	.48000E+04
30	.27669E+05	.89908E+02	.24041E+05	.18930E+03	.70000E+03	.49000E+03	.74000E+03	.12900E+04	0.	.60000E+04
31	.22255E+05	.10720E+03	.18620E+05	.14662E+03	.20000E+02	.20600E+04	.12900E+04	.19400E+04	.10000E+01	.10000E+05
32	.22616E+05	.86450E+02	.22391E+05	.17631E+03	.60000E+03	.34200E+04	.60000E+03	.31000E+04	0.	.75000E+04
33	.16842E+05	.51870E+02	.15085E+05	.11878E+03	.65000E+03	.41300E+04	.72000E+03	.10150E+05	0.	.48000E+04
34	.28270E+05	.12968E+03	.29109E+05	.22920E+03	.87000E+03	.94000E+03	.89000E+03	.46200E+04	0.	.80000E+04
35	.30676E+05	.10720E+03	.28991E+05	.22828E+03	.98000E+03	.32000E+03	.40000E+03	.10600E+04	0.	.60000E+04
36	.28872E+05	.17290E+03	.20034E+05	.15775E+03	.99000E+03	.97000E+03	.40000E+03	.67000E+03	0.	.60000E+04
37	.48120E+05	.25935E+03	.46197E+05	.36376E+03	.85000E+03	.50000E+03	.90000E+03	.61000E+04	0.	.80000E+04
38	.37293E+05	.31641E+03	.33469E+05	.26354E+03	.20000E+02	.28100E+04	.14200E+04	.88500E+04	.10000E+01	.13500E+05
39	.31278E+05	.77805E+02	.25691E+05	.20229E+03	.13200E+04	.12200E+04	.25000E+03	.26500E+04	0.	.60000E+04
40	.21052E+05	.86450E+02	.18502E+05	.14569E+03	.95000E+03	.26700E+04	.56000E+03	.87200E+04	0.	.60000E+04
41	.25864E+05	.77805E+02	.21331E+05	.16796E+03	.17700E+04	.11000E+04	.25000E+03	.67000E+03	0.	.50000E+04
42	.49323E+05	.25935E+03	.47847E+05	.37675E+03	.20000E+02	.23700E+04	.14200E+04	.31000E+04	.10000E+01	.20000E+05
43	.28872E+05	.77805E+02	.28166E+05	.22178E+03	.52000E+03	.13000E+04	.73000E+03	.21000E+04	0.	.60000E+04
44	.22255E+05	.77805E+02	.19799E+05	.15590E+03	.98000E+03	.36400E+04	.55000E+03	.97000E+04	0.	.60000E+04
45	.24060E+05	.89908E+02	.27341E+05	.21528E+03	.71000E+03	.11300E+04	.73000E+03	.19000E+04	0.	.60000E+04
46	.36090E+05	.11238E+03	.32173E+05	.25333E+03	.10700E+04	.70000E+03	.67000E+03	.67500E+04	0.	.90000E+04
47	.23458E+05	.62244E+02	.15910E+05	.12527E+03	.20800E+04	.33000E+04	.57000E+03	.94500E+04	0.	.40000E+04
48	.16240E+05	.14697E+03	.16381E+05	.12899E+03	.55000E+03	.37700E+04	.88000E+03	.98500E+04	0.	.48000E+04
49	.29895E+05	.77805E+02	.27223E+05	.21436E+03	.10700E+04	.43000E+03	.53000E+03	.38800E+04	0.	.60000E+04
50	.42105E+05	.17290E+03	.40069E+05	.31550E+03	.86000E+03	.66000E+03	.72000E+03	.37000E+04	0.	.90000E+04
51	.21052E+05	.77805E+02	.19681E+05	.15497E+03	.94000E+03	.27000E+04	.57000E+03	.87700E+04	0.	.60000E+04
52	.25263E+05	.96824E+02	.21331E+05	.16796E+03	.33000E+03	.50000E+03	.10700E+04	.11900E+04	0.	.60000E+04
53	.36090E+05	.12103E+03	.31937E+05	.25147E+03	.54000E+03	.[illegible]7600E+04	.10500E+04	.78000E+04	0.	.96000E+04
54	.27669E+05	.77805F+02	.22156E+05	.17445E+03	.12000E+04	.10300E+04	.25000E+03	.16500E+04	0.	.60000E+04
55	.54135E+05	.43225E+03	.51383E+05	.40459E+03	.37000E+03	.11700E+04	.11800E+04	.37700E+04	0.	.12000E+05
56	.32481E+05	.10374E+03	.29934E+05	.23570E+03	.45000E+03	.19500E+04	.92000E+03	.17300E+04	0.	.60000E+04
57	.55338E+05	.17290E+03	.48554E+05	.38232E+03	.10800E+04	.11200E+04	.74000E+03	.49500E+04	0.	.15000E+05
58	.27067E+05	.86450E+02	.24395E+05	.19209E+03	.13200E+04	.19100E+04	.25000E+03	.79000E+04	0.	.75000E+04
59	.19849E+05	.51870E+02	.18738E+05	.14754E+03	.48000E+03	.12200E+04	.12300E+04	.71400E+04	0.	.10800E+05
60	.32481E+05	.19884E+03	.25927E+05	.20415E+03	.89000E+03	.16500E+04	.56000E+03	.23500E+04	0.	.60000E+04
61	.25864E+05	.11238E+03	.24748E+05	.19487E+03	.56000E+03	.82000E+03	.89000E+03	.16400E+04	0.	.60000E+04
62	.15037E+05	.51870E+02	.14613E+05	.11507E+03	.10200E+04	-0.	.54000E+03	-0.	0.	.30000E+04
63	.20451E+05	.77805E+02	.22627E+05	.17817E+03	.84000E+03	.33000E+03	.53000E+03	.11000E+04	0.	.54000E+04
64	.18045E+05	.13832E+03	.18856E+05	.14847E+03	.20000E+02	.38900E+04	.13500E+04	.99300E+04	.10000E+01	.12000E+05
65	.25263E+05	.17290E+03	.21802E+05	.17167E+03	.85000E+03	.35000E+04	.35000E+03	.30700E+04	0.	.50000E+04
Mean	28,049	115	26,241	207	792	1690	737	4620	0.09	7878
Standard Deviation:	10,722	71.3	10,178	80.1	434	1234	355	3445	0.29	5671

Table K-11. SAMPLE DATA - DUNBAR SITE

Observation Number	V_{60}	T_{60}	V_{70}	T_{70}	Distance to Water (ft.)	Distance to nearest School (ft.)	Distance to Central Business District (ft.)	Distance to Bridge access (ft.)	Distance to Highway access (ft.)	Distance to Railroad(ft.)	Lot Area (sq. ft.)
1	.22616E+05	.29393E+02	.16546E+05	.13826E+03	.20000E+02	.29000E+04	.94000E+04	.10450E+05	.10650E+05	.37500E+04	.16000E+05
2	.23458E+05	.10028E+03	.21322E+05	.17816E+03	.20000E+02	.18000E+04	.14500E+05	.15500E+05	.15500E+05	.10000E+04	.10400E+05
3	.14616E+05	.51870E+02	.14881E+05	.12434E+03	.10500E+04	.12000E+04	.12500E+05	.13800E+05	.12800E+05	.15000E+04	.40000E+04
4	.19849E+05	.63973E+02	.19767E+05	.16517E+03	.80000E+03	.80000E+03	.10500E+05	.11750E+05	.11400E+05	.25000E+04	.90000E+04
5	.96240E+04	.43225E+02	.11105E+05	.92793E+02	.12000E+04	.36000E+04	.22500E+04	.80000E+03	.38000E+04	.24000E+04	.28800E+04
6	.18045E+05	.10374E+03	15547E+05	.12991E+03	.65000E+03	.21000E+04	.15300E+05	.14700E+05	.13500E+05	.90000E+03	.50000E+04
7	.23458E+05	.77805E+02	.29095E+05	.24312E+03	.15000E+04	.40000E+03	.10900E+05	.12300E+05	.11600E+05	.16000E+04	.75000E+04
8	.25263E+05	.65702E+02	.23320E+05	.19487E+03	.10000E+04	.32000E+04	.25000E+04	.20500E+04	.49000E+04	.34000E+04	.40000E+04
9	.22255E+05	.60515E+02	.17102E+05	.14290E+03	.18000E+04	.25000E+04	.50000E+04	.58000E+04	.67000E+04	.30000E+04	.60000E+04
10	.13233E+05	.20748E+02	.10661E+05	.89082E+02	.19000E+04	.32000E+04	.15500E+04	.30000E+03	.31500E+04	.17500E+04	.30000E+04
11	.13233E+05	.51870E+02	.12104E+05	.10114E+03	.70000E+03	.13000E+04	.10200E+05	.11500E+05	.11300E+05	.29000E+04	.45000E+04
12	.17443E+05	.69160E+02	.15547E+05	.12991E+03	.11000E+04	.12500E+04	.14200E+05	.15500E+05	.14500E+05	.55000E+03	.72000E+04
13	.96240E+04	.43225E+02	.11105E+05	.92793E+02	.16000E+04	.90000E+03	.12500E+05	.13700E+05	.12900E+05	.90000E+03	.65000E+04
14	.13834E+05	.63973E+02	.14881E+05	.12434E+03	.17000E+04	.65000E+03	.10450E+05	.11800E+05	.11200E+05	.16000E+04	.50000E+04
15	.16842E+05	.69160E+02	.14548E+05	.12156E+03	.20000E+04	.12000E+04	.11050E+05	.12600E+05	.11600E+05	.10000E+04	.40000E+04
16	.25864E+05	.69160E+02	.22321E+05	.18651E+03	.20000E+02	.36000E+04	.60000E+04	.78000E+04	.64000E+04	.44000E+04	.12750E+05
17	.53654E+04	.34580E+02	.10106E+05	.84442E+02	.17500E+04	.21000E+04	.45500E+04	.52000E+04	.63000E+04	.29000E+04	.36000E+04
18	.16842E+05	.69160E+02	.13326E+05	-11135E+03	.16500E+04	.90000E+03	.11000E+05	.12600E+05	.11700E+05	.13500E+04	.40000E+04
19	.15639E+05	.55328E+02	.12882E+05	.10764E+03	.70000E+03	.85000E+03	.10500E+05	.11800E+05	.11500E+05	.27000E+04	.45000E+04
20	.11428E+05	.13832E+02	.11882E+05	.99289E+02	.18500E+04	.31000E+04	.80500E+04	.92500E+04	.92000E+04	.24500E+04	.36000E+04
21	.16361E+05	.63973E+02	.15769E+05	.13177E+03	.15000E+04	.29000E+04	.53000E+04	.60000E+04	.70000E+04	.32500E+04	.60000E+04
22	.31879E+05	.10374E+03	.25986E+05	.21714E+03	.19500E+04	.21000E+04	.88000E+04	.10050E+05	.97000E+04	.20000E+04	.60000E+04
23	.14436E+05	.51870E+02	.14881E+05	.12434E+03	.14500E+04	.32000E+04	.83000E+04	.93000E+04	.95000E+04	.28500E+04	.72000E+04
24	.21654E+05	.70889E+02	.17102E+05	.14290E+03	.14000E+04	.14000E+04	.96000E+04	.10900E+05	.10550E+05	.22000E+04	.67500E+04
25	.24060E+05	.86450E+02	.15991E+05	.13362E+03	.14000E+04	.17000E+04	.36000E+04	.40000E+04	.55500E+04	.31000E+04	.42000E+04
26	.13834E+05	.51870E+02	.15103E+05	.12620E+03	.16000E+04	.46000E+04	.70000E+04	.80000E+04	.84500E+04	.30000E+04	.36000E+04
27	.72180E+04	.29393E+02	.25541E+05	.21342E+03	.19000E+04	.34500E+04	.59000E+04	.68500E+04	.74000E+04	.29000E+04	.82000E+04
28	.90225E+04	.72618E+02	.13548E+05	.11321E+03	.70000E+03	.95000E+03	.14300E+05	.15900E+05	.14900E+05	.10000E+04	.40000F+04
29	.21052E+05	.84721E+02	.13992E+05	.11692E+03	.11000E+04	.15000E+04	.98000E+04	.10900E+05	.10750E+05	.26000E+04	.10000E+05
Mean:	17,174	61.1	16,412	137	1242	2047	8810	9693	9807	2257	6186
Standard Deviation:	6282	23.0	4904	41.0	591	1120	3852	4349	3308	980	3079

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Table K-12. SAMPLE DATA - BEAVER SITE

Observation Number	V_{60}	T_{60}	V_{70}	T_{70}	Distance to Water (ft.)	Distance to State Street (ft.)	Distance to Agnew Sq. (ft.)	Distance to Railroad Station (ft.)	Distance to High School (ft.)	Distance to nearest corner Park (ft.)	Lot Area (sq. ft.)
1	.21475E+05	.31571E+03	.23404E+05	.51800E+03	.90000E+03	0.	.26000E+04	.40000E+03	.56000E+04	.14000E+04	.92400E+04
2	.19626E+05	.28820E+03	.17897E+05	.47300E+03	.70000E+03	.10000E+04	.11000E+04	.28000E+04	.40500E+04	.11500E+04	.53750E+04
3	.19522E+05	.28689E+03	.28300E+05	.47000E+03	.55000E+03	.10000E+04	.15500E+04	.42000E+04	.31500E+04	.30000E+03	.82800E+04
4	.37450E+05	.55020E+03	.29652E+05	.90300E+03	.95000E+03	.50000E+03	.19000E+04	.11000E+04	.50000E+04	.80000E+03	.14250E+05
5	.16708E+05	.24497E+03	.20118E+05	.40300E+03	.11000E+04	.50000E+03	.50000E+03	.29000E+04	.36000E+04	.15000E+04	.32450E+04
6	.17672E+05	.25938E+03	.16500E+05	.42600E+03	.10000E+04	.40000E+03	.20000E+04	.50000E+04	.24000E+04	.90000E+03	.67200E+04
7	.23171E+05	.34060E+03	.23000E+05	.55900E+03	.90000E+03	.25000E+03	.30000E+04	.60000E+04	.23000E+04	.18000E+04	.70000E+04
8	.26393E+05	.38776E+03	.36006E+05	.63700E+03	.70000E+03	.45000E+03	.40000E+04	.70000E+04	.28000E+04	.26500E+04	.61600E+04
9	.19929E+05	.29344E+03	.23298E+05	.48100E+03	.20000E+04	.40000E+03	.60000E+03	.35000E+04	.26000E+04	.12500E+04	.46200E+04
10	.20695E+05	.30392E+03	.28740E+05	.49900E+03	.95000E+03	.50000E+03	.21000E+04	.10000E+04	.51000E+04	.90000E+03	.52000E+04
11	.26381E+05	.38776E+03	.32299E+05	.63600E+03	.30000E+03	.95000E+03	.27000E+04	.90000E+03	.58000E+04	.11000E+04	.80010E+04
12	.20834E+05	.30654E+03	.23827E+05	.50300E+03	.10500E+04	.40000E+03	.18000E+04	.47000E+04	.24000E+04	.90000E+03	.75000E+04
13	.12661E+05	.18602E+03	.15232E+05	.30500E+03	.70000E+03	.50000E+03	.26000E+04	.60000E+03	.56000E+04	.13000E+04	.72000E+04
14	.11312E+05	.16637E+03	.17500E+05	.27300E+03	.15000E+04	0.	.50000E+03	.36000E+04	.28000E+04	.14000E+04	.43680E+04
15	.17917E+05	.26331E+03	.23827E+05	.43200E+03	.55000E+03	.90000E+03	.21000E+04	.13000E+04	.52000E+04	.50000E+03	.69000E+04
16	.15208E+05	.22401E+03	.12646E+05	.36700E+03	.11000E+04	0.	.26500E+04	.56000E+04	.20000E+04	.16500E+04	.51000E+04
17	.20533E+05	.30130E+03	.26475E+05	.49500E+03	.16500E+04	.10000E+03	.14500E+04	.44000E+04	.20500E+04	.10500E+04	.18000E+05
18	.12649E+05	.18602E+03	.15885E+05	.30500E+03	.19000E+04	.30000E+03	.12000E+04	.19500E+04	.40000E+04	.15500E+04	.23400E+04
19	.19243E+05	.28296E+03	.14370E+05	.46400E+03	.80000E+03	.60000E+03	.16000E+04	.46000E+04	.27000E+04	.60000E+03	.58240E+04
20	.22254E+05	.32750E+03	.25416E+05	.53700E+03	.85000E+03	.30000E+03	.32000E+04	.62000E+04	.23000E+04	.19000E+04	.75600E+04
21	.10545E+05	.15458E+03	.95800E+04	.25400E+03	.10000E+04	.25000E+03	.24000E+04	.54000E+04	.22000E+04	.13000E+04	.35000E+04
22	.36380E+05	.53448E+03	.38320E+05	.87800E+03	.80000E+03	.65000E+03	.20000E+04	.12000E+04	.51000E+04	.70000E+03	.19000E+04
23	.59553E+05	.87508E+03	.43800E+05	.14360E+04	.25000E+03	.13500E+04	.15000E+04	.26000E+04	.46000E+04	.75000E+03	.15720E+05
24	.19055E+05	.28034E+03	.23471E+05	.46000E+03	.18000E+04	.45000E+03	.24000E+04	.90000E+03	.51000E+04	.12500E+04	.62000E+04
25	.21463E+05	.31571E+03	.26000E+05	.51800E+03	.25000E+03	.80000E+03	.39000E+04	.68000E+04	.31000E+04	.24000E+04	.68000E+04
26	.21870E+05	.32095E+03	.23000E+05	.52800E+03	.12000E+04	0.	.26000E+04	.55000E+04	.20000E+04	.16000E+04	.51000E+04
27	.11312E+05	.16637E+03	.10590E+05	.27300E+03	.20000E+04	.45000E+03	.17500E+04	.14500E+04	.45000E+04	.80000E+03	.56400E+04
28	.20638E+05	.30392E+03	.18202E+05	.49800E+03	.11000E+04	.40000E+03	.16000E+04	.15000E+04	.47000E+04	.80000E+03	.86400E+04
29	.17951E+05	.26331E+03	.26475E+05	.43300E+03	.11000E+04	0.	.27000E+04	.56000E+04	.20000E+04	.16000E+04	.75000E+04
30	.20183E+05	.29606E+03	.18873E+05	.48700E+03	.70000E+03	.75000E+03	.13500E+04	.41000E+04	.30000E+04	.50000E+03	.59400E+04
31	.13696E+05	.20174E+03	.22000E+05	.33000E+03	.12500E+04	0.	.22000E+04	.52000E+04	.20000E+04	.13500E+04	.46500E+04
32	.23266E+05	.34191E+03	.27534E+05	.56100E+03	.95000E+03	.50000E+03	.17500E+04	.47000E+04	.25000E+04	.80000E+03	.67500E+04
33	.13405E+05	.19650E+03	.15885E+05	.32300E+03	.60000E+03	.95000E+03	.10000E+04	.28500E+04	.40000E+04	.12000E+04	.56250E+04
34	.75574E+04	.11135E+03	.12178E+05	.18200E+03	.11000E+04	.35000E+03	.13500E+04	.43000E+04	.25500E+04	.80000E+03	.30000E+04
35	.21568E+05	.31702E+03	.24870E+05	.52000E+03	.16500E+04	0.	.14500E+04	.15000E+04	.44000E+04	.11000E+04	.29380E+04
36	.21416E+05	.31440E+03	.26824E+05	.51700E+03	.20000E+04	.40000E+03	.16000E+04	.15500E+04	.43500E+04	.75000E+03	.55000E+04
37	.23207E+05	.34060E+03	.30656E+05	.56000E+03	.19500E+04	.35000E+03	.15000E+04	.15000E+04	.43000E+04	.80000E+03	.82500E+04
38	.18057E+05	.26593E+03	.18000E+05	.43600E+03	.11000E+04	.50000E+03	.85000E+03	.37000E+04	.30000E+04	.10000E+04	.62500E+04
39	.22660E+05	.33274E+03	.19000E+05	.54700E+03	.85000E+03	.65000E+03	.18000E+04	.13500E+04	.49500E+04	.65000E+03	.43000E+04
40	.24172E+05	.35501E+03	.27269E+05	.58300E+03	.25000E+03	.95000E+03	.28000E+04	.80000E+03	.59000E+04	.12500E+04	.80010E+04
41	.17881E+05	.26331E+03	.22992E+05	.43100E+03	.65000E+03	.50000E+03	.26500E+04	.40000E+03	.57000E+04	.14000E+04	.66650E+04
42	.30532E+05	.44933E+03	.37065E+05	.73600E+03	.40000E+03	.80000E+03	.29500E+04	.58000E+04	.27500E+04	.14500E+04	.50000E+04
43	.18289E+05	.26855E+03	.18200E+05	.44100E+03	.90000E+03	.30000E+03	.33000E+04	.52500E+04	.23000E+04	.21000E+04	.70000E+04
44	.11080E+05	.16244E+03	.14826E+05	.26700E+03	.19000E+04	.30000E+03	.13500E+04	.17000E+04	.42000E+04	.90000E+03	.39000E+04
45	.20292E+05	.29868E+03	.28593E+05	.48900E+03	.14500E+04	.20000E+03	.90000E+03	.20500E+04	.40000E+04	.11500E+04	.79200E+04
46	.18881E+05	.27772E+03	.21500E+05	.45500E+03	.25000E+03	.12000E+04	.23500E+04	.13500E+04	.55000E+04	.60000E+03	.44000E+04
47	.22985E+05	.33798E+03	.23950E+05	.55400E+03	.18000E+04	.60000E+03	.28000E+04	.85000E+03	.54000E+04	.15000E+04	.61200E+04
48	.12917E+05	.18995E+03	.11735E+05	.31200E+03	.12000E+04	.40000E+03	.65000E+03	.35000E+04	.30500E+04	.12000E+04	.40000E+04
49	.14800E+05	.21746E+03	.14296E+05	.35700E+03	.90000E+03	.60000E+03	.18000E+04	.47000E+04	.25500E+04	.70000E+03	.56250E+04
50	.21056E+05	.30916E+03	.21076E+05	.50800E+03	.10000E+04	.45000E+03	.19000E+04	.48500E+04	.23500E+04	.90000E+03	.84000E+04
51	.13894E+05	.20436E+03	.14296E+05	.33500E+03	.19500E+04	.40000E+03	.12000E+04	.41500E+04	.20000E+04	.80000E+03	.33600E+04
52	.14662E+05	.21615E+03	.20121E+05	.35400E+03	.80000E+03	.65000E+03	.18000E+04	.47000E+04	.26500E+04	.65000E+03	.57000E+04
53	.23171E+05	.34060E+03	.27534E+05	.55900E+03	.30000E+03	.85000E+03	.32000E+04	.60000E+04	.28500E+04	.17000E+04	.92000E+04
Mean:	20,189	297	22,511	487	1048	492	1972	3312	3604	1152	6460
Standard Deviation:	7959	117	7323	192	518	321	832	1957	1279	482	2969

SELECTED WATER RESOURCES ABSTRACTS

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1. Rep t No.

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5. R. ort Da e

6.

8. Performing Organ zation Report No.

Benefit of Water Pollution Control on Property Values

D. M. Dornbusch and S. M. Barrager

01AAB-07

David M. Dornbusch and Company
San Francisco, CA

68-01-0753

13. Type c Report and Period Covered

12. Sponsoring Organiza on

Environmental Protection Agency report number,
EPA-600/5-73-005, October 1973.

This study was undertaken to determine the current state-of-knowledge concerning the measurement of the potential benefit of water pollution control on property values, and to analyze the relationship between water quality parameters and property values at several sites where water pollution has been substantially reduced in recent years. Multiple-regression analysis and an interview technique were employed to study the relationship between residential and recreational property values and water quality components. Study sites were located on San Diego Bay and the Kanawha, Ohio, and Willamette Rivers. It was found that effective pollution abatement on badly polluted water bodies can increase the value of single-family homes situated on waterfront lots by 8 to 25 percent, and that these water quality improvements can affect property values up to 4000 feet away from the water's edge. It was also found that the measurable water quality parameters which have the greatest influence on property values are dissolved oxygen concentration, fecal coliform concentrations, clarity, visual pollutants (trash and debris), toxic chemicals, and pH.

Case study results were combined with a 1971 EPA water pollution survey to estimate the national benefit expressed in increased residential, recreational and rural waterfront property values, to be gained from water pollution abatement. The estimated capital value of the benefit ranges from .6 to 3.1 billion dollars, with a most likely benefit of 1.3 billion dollars.

17a. Descriptors

*Water Quality, *Water Quality Control, *Economics, *Benefits, *Property Values

17b. Identifiers

19. Security Class. (Report)

20. Security Class. (Page)

21. No. of Pages 148

22. Price

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