SECTION 6

BENEFIT MEASUREMENT

6.1 THEORY

Given the property value relation, benefits can be estimated for a change in air quality. Some studies have used the property value equation directly to estimate benefits due to changes in pollution levels. More recently, an approach more closely linked to theory of demand has been used. This approach (first presented by Harrison and Rubenfeld, 1978) involves several steps. The hedonic (property) value equation is first estimated. Then, marginal hedonic values or "hedonic" prices are derived and used to estimate benefits. These steps are described below.

The general specification of the hedonic value equation used here is

$$\log PV = \Sigma a_i \log Z_i + \Sigma b_i z_i^2,$$

that is, "good" characteristies are transformed by taking logarithms and "bad" characteristics are squared. Then, the marginal value of a "good" characteristic is

$$\frac{\partial PV}{\partial z_i} = a_i \frac{PV}{z_i} ;$$

for a "bad" such as pollution, the marginal value is

$$\frac{\partial PV}{\partial z_i} = |2b_i z_i| PV$$

In the next step, following the Harrison and Rubenfeld method[12] marginal values (hedonic prices) are then regressed against quantity'of pollution and income to obtain an inverse demand function. This inverse demand function is then used to obtain a benefit measure by integrating it between the original and the changed pollution values.

The advantage of the multiple step approach is that a nonmarginal change can be evaluated using a demand concept. It also explicitly recognizes differences in income and tastes in obtaining benefit measures. The estimated benefit measure, based on the work by Willig (1976), is an approximation of an exact benefit measure. In comparison, some past applications which used the property value equation directly were linear and so assumed a constant value per unit air quality change.

There are some econometric problems with the multiple step benefit estimation method. There is a problem with the error term in the second estimation step (Saxonhouse, 1976). Another issue is simultaneity; from theory, all characteristics demanded are simultaneously determined. Some recent studies (although not pollution studies) have used two and three stage methods to account for simultaneity (Witte, 1979).

6.2 MEASUREMENT OF INVERSE DEMAND EQUATIONS

Pollution studies usually have limited information available as to socioeconomic characteristics of home buyers; for example studies have had to use out of date census data for income information. (Because of such limitations, the Brookshire study used the hedonic equation with city level income data to estimate the effects of income and pollution level on willingness to pay (Table 31a).) We were fortunate to have access to two data sets (see the appendix for a description of each). The Market Data Center (MDC) data contained detailed information about house characteristics but did not include buyer characteristics. Current age and income information for home buyers was available from the Savings and Loan data. Thus, we could carry out the derivation of demand relations at the individual household level with accurate income data.

The only house level characteristic available from the Savings and Loan were living area and house age. We estimated the property value equation using the MDC data but using only those house characteristics (age and living area) corresponding to the Savings and Loan information; all other tract and city level variables were used. Table 30 shows the results of this estimation. With the use of living area and age of house, very little explanatory power is lost due to omission of other household level characteristics (an R-squared of .86 compared to .88). Also, the coefficients of the other independent variables (including the OZONE pollution measure) are nearly the same with and without detailed household level characteristic information.

The data from the Savings and Loan regarding house size and price were shown not to differ significantly from corresponding data obtained from the Market Data Center. Thus, it was appropriate to combine coefficients from Table 30 and Savings and Loan data on sales price and socioeconomic variables for the inverse demand estimation. The same tracts were used for demand estimation as in the household level hedonic value regression.[13]

Table 30

Household Model for Benefit Measurement, OZONE

DEP VAR: LPROPVAL					
		SSE	63.854910	F RATIO	688.80
		DFE	2497	PROB>F	0.0001
		MSE	0.025573	R-SQUARE	0.8585

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-3.724212	0.515768	-7.2207	0.0001
LLIVAREA	1	0.741606	0.011625	63.7957	0.0001
ELEV1	1	0.043265	0.019720	2.1940	0.02[illegible]3
SSLOPE	1	-0.000215418	.00004876715	-4.4173	0.0001
LHEOSCHT	1	0.703426	0.090706	7.7550	0.0001
LTAX	1	0.372509	0.069764	5.3407	0.0001
LSCORES	1	0.485340	0.110910	4.3760	0.0001
NEWHISPT	1	-0.00250106	0.000277832	-9.0021	0.0001
VAC	1	-0.044893	0.007164454	-6.2660	0.0001
DEVEL	1	0.019366	0.050131	0.3863	0.6993
LMODEV	1	0.012342	0.004073066	3.0302	0.0025
SHSEAGE	1	-0.000050663	.00000487854	-10.3849	0.0001
SPCTPOV	1	-0.00149715	.00007960359	-18.8063	0.0001
SHONRES	1	-0.872803	0.272303	-3.2043	0.0014
SHEDOCCT	1	-0.00502393	0.001763535	-2.8488	0.0044
SDIST	1	-1.23474E-08	8.76966E-09	-1.4080	0.159[illegible]
SCRIMRA	1	-27.321902	2.055130	-13.2945	0.0001
QTR1	1	-0.017295	0.009488981	-1.8226	0.068[illegible]
QTR2	1	0.038714	0.009360289	4.1360	0.0001
QTR3	1	0.051313	0.009151054	5.6073	0.0001
MKT1	1	0.225612	0.019400	11.6294	0.0001
OZONE	1	-.0000018741	3.77369E-07	-4.9663	0.0001
URBAN	1	0.166087	0.022855	7.2671	0.0001

The inverse demand equation for a characteristic was obtained by regressing the marginal property value[14] for the characteristic (ozone, nonresidential landuse, distance to work, living area) against the characteristic, buyer income, and buyer age (to account for differences in tastes); a log-log model was used (see Table 31b). In spite of having a much larger number of observations than in the Los Angeles study, our inverse demand equation for ozone has a larger R^2. All exploratory variables are significant at the 99 percent level. The inverse demand relations for other characteristics (nonresidential land use, distance to work, and house size) had lower R^2 values.

Since the marginal value equations are in “logs”, a coefficient indicates the percent change in <u>marginal</u> value for a percent change in the variable. For the “good” characteristic (house size), the slope of the inverse demand is negative. For the remaining “bad” characteristics, the slope is positive indicating that the marginal value increases as the characteristic worsens. The slope for OZONE is similar to that for distance to work; the equation for living area has the smallest slope. The effect of a percent change in income on percent change in willingness to pay is similar for all three "bads"; the effect of a percent change in income on willingness to pay for living area is much lower.

Income elasticity for a characteristic is the ratio of the coefficient of income to the coefficient of the characteristic. Thus, living area is more income elastic than OZONE; a given percent change in income will have a greater effect on demand for living area than for air quality. Our income elasticity (.277) for OZONE is much smaller than that obtained in the Los Angeles study (1.314). For a given percent change in income, a much smaller effect on demand for air quality (in terms of percent change) is predicted in San Francisco as compared to Los Angeles. These results are not surprising in light of the difference in air quality between the two areas but differences may also be due to the aggregate nature of the income data used for the Los Angeles study.

6.3 ESTIMATION OF BENEFITS

Benefits were computed for both an improvement and deterioration in air quality of 30 percent. (The thirty percent value was chosen for comparability to the Los Angeles study where each of the air quality categories was about thirty percent different from the adjacent category.) Both changes in OZONE and PS12 were evaluated. For comparison purposes, Table 32 gives the average air quality (PSI2 and OZONE) for urban/suburban and East Bay/West Bay areas. Several alternative methods of benefit measurement are presented for comparison purposes.

<u>6.3.1 Estimation of Average Household Benefits Using the Property Value Equation Directly</u>

Previously, the direct change in property values was used to estimate the benefits of a change in pollution in terms of property values. Usually a linear hedonic model was used and this tended to overstate benefits. We

Table 31a

DEMAND EQUATION
LOS ANGELES

Dependent Variable = Log (Marginal Willingness to Pay in Dollars)		
Independent Variable	Coefficient	t-statistic
Constant	-6.4845	-5.7025
Log (Income**)	1.1473	13.092
Log (NO_2)	.87283	6.1051

R^2 = .942

Degrees of Freedom = 11

* These equations are based on the hedonic housing value equation which utilizes $(NO_2)^2$ as the air pollution measure.

** The income variable is defined as average community income and in dollars.

Table 31b

DEMAND EQUATIONS, SELECTED CHARACTERISTICS,
BAY AREA

MODEL: OZ	SSE	197.943499	F RATIO	9826.07
	OFE	2051	PROB>F	0.0001
DEP VAR: MUOZ	MSE	0.096511	R-SQUARE	0.9599

VARIABLE	0?	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-8.345120	0.140693	-59.3144	0.0001
LNAGE	1	0.053788	0.020155	2.6688	0.0077
LNINC	1	0.276709	0.016065	17,2247	0.0001
LOZONE	1	1.004124	0.006843484	146.7270	0.0001
URBAN	t	-0.173446	0.023069	-7.5252	0.0001
MKT1	1	0.213426	0.015492	13.7766	0$0001

MODEL: NRES	SSE	159.380718	F RATIO	1416.66
	OFE	2051	PROB>F	0.0001
OEP VAR: MUNONRES	MSE	0.077709	R-SQUARE	0.7755

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	4.650969	0.125244	37.1352	0.0001
LNAGE	1	0.052057	0.018083	2.8788	0.0040
LNINC	1	0.223455	0.014554	15.3531	0.0001
LNONRES	1	0.784361	0.009675654	81.0655	0.0001
URBAN	1	-0.214312	0.015269	-14.0361	0.0001
MKT1	t	0.160851	0.012717	12.6459	0.0001

MODEL: 01S1	SSE	197.914807	F RATIO	409.31
	DFE	2051	PROB>F	0.0001
DEP VAR: MUDIST	MSE	0.096497	R-SQUARE	0.4995

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-13.S72993	0.300469	-45.1727	0.0001
LNAGE	1	0.054171	0.020152	2.6881	0.0072
LNINC	1	0.277272	0.015997	17.3329	0.0001
LDIST	1	1.030460	0.037480	27.4936	0.0001
URBAN	1	-0.174855	0.019598	-S.9220	0.0001
MKT1	1	0.214066	0*015104	14.1725	0.0001

MODEL: LIV	SSE	60.615094	F RATIO	218.16
	DFE	2051	PROB>F	0.0001
DEP VAR: MULIV	MSE	0.029554	R-SQUARE	0.3472

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	-0.593522	0.101151	-5.6677	0.0001
LNAGE	1	0.006399981	0.011173	0.5728	0.5669
LNINC	1	0.08S053	0.009289442	9.1s59	0.0001
LLIVAREA	1	-0.151430	0.012447	-12.1661	0.0001
URBAN	1	-0.116220	0.009426649	-12.3289	0.0001
MKT1	1	0.207625	0.007726484	26.6719	0.0001

Table 31b (continued)

Dependent variables:

Muoz = log (marginal value of a change in OZONE)

MUNONRES = log (marginal value of an increase" in nonresidential land use)

MUDIST = log (marginal value of an increase in distance to work)

MULIV = log (marginal value of an increase in living area)

Independent variables (LN denotes logarithm):

AGE = age of buyer, Savings and Loan data

INC = monthly income of buyer, Savings and Loan data

OZONE = measure of ozone pollution (not squared)

URBAN = 1 denotes an urban area

MKTI = 1 denotes West Bay location

NONRES = percent of land in nonresidential use

DIST = expected distance to employment

LIVAREA = living area of house

Table "32

Average[a] Air Quality by Area

	A	B	C	D	E
West Bay					
Suburban					
PS12	6.4	9.2	11.3	15.7	33.27
OZONE	27.0	6.5	27.0	63.4	210.20
Urban					
PSI 2		6.6			
OZONE		4.6			
East Bay					
Suburban					
PS12	6.7	7.8	16.8	19.4	
OZONE	14.0	19.2	149.9	82.4	
Urban					
PSI2		5.9			
OZONE		9.6			

[a]Average is computed from city values weighted by population.

also have used the hedonic equation directly to obtain the estimated property value change; however, a log-log hedonic, rather than linear, model was used. (The master tract level regression was most appropriate for this estimation since we are extrapolating benefits to the whole Bay Area.)

Tables 33 and 34 show the resulting average annual household benefits for PSI2 and OZONE. (Benefits were computed for all sales in each tract and then averaged to obtain the representative tract value.) Generally, the benefit measures follow the same pattern as the air quality categories. For PSI2, the benefits of a change in air quality increase from area A to E with the exception of the East Bay air quality area B; tracts in area B are of lower socioeconomic status than area A. The benefit measures for OZONE reflect the air quality categorization problems noted above. The benefit measures for OZONE are generally smaller than the corresponding measures for PS12 since PS12 includes more pollutants.

The measure of the property value gain associated with a 30 percent improvement is lower than the measure of the property value loss with a 30 percent deterioration. Generally, the deterioration measure is about three times the improvement measure. This difference reflects the nonlinearity of the property value equation.

6.3.2 Household Benefit Measures Using the Inverse Demand Relation

The inverse demand relation for ozone described above was also used to derive benefit measures. The equation is of the form

$$\log MV = a \log AGE + b \log INCOME + c \log POLLUTION + d\,URBAN + e MKT1 + f$$

where Q denotes the measure of pollution and the coefficients are given in Table 31 b. The benefit function is obtained by evaluating the integral of the demand equation between the original and changed pollution values. Here,

$$\int_{Q_o}^{Q_o + \Delta Q} MVdQ = \exp(dURBAN + eMKTl + f) AGE^{a}\ INCOME^{b}\ Q_o^{\ c+1}/c+1\ [(1 + \Delta Q)^{c+1} - 1]$$

After evaluating benefits for each sale in our data set, we averaged household benefits by air quality and market area. Table 35 shows the average values using pollution changes of plus and minus 30 percent. The estimates of benefits so obtained may be compared with those using the property value equation directly. Using the demand method, the benefits of avoiding an increase are generally smaller than with the direct method whereas the benefits of obtaining a decrease are larger.

Since other studies have used city level data to evaluate benefits, we also calculated benefits at the city level using average age and income by city. Table 36 shows the estimated average household benefits by area

Table 33

Average Annual[c] Benefit Per Household (dollars)
Direct Property Value Method, Tract Level Data
PS12

	A	B	C	D	
West Bay					
Suburban	28.63;	89.25	154.22	280.58	856.32
	8.65	27.11	46.96	86.23	281.54
Urban		44.33			
		13.40			
East Bay					
Suburban	42.94	34.06	217.42	263.92	
	13.01	10.31	67.47	82.09	
Urban		25.04			
		7.58			

a. Avoid 30% increase in PS12 b. Obtain 30% decrease in PS12

c. Using a .6995 capital recovery factor which is based on an interest rate of 9.25% and a 30 year payback.

Table 34

Average Annual[c] Benefit Per Household (dollars)
Direct Property Value Method, Tract Level Data
OZONE

	A	B	C	D	E
West Bay					
Suburban					
	15.56[a]	4.36	13.77	105.86	539.31
	4.69[b]	1.32	4.16	32.48	172.32
Urban					
		.30			
		.09			
East Bay					
Suburban					
	3.31	3.98	230.57	97.60	
	.95	1.20	71.44	29.97	
Urban					
		1.67			
		.50			

a. Avoid 30% increase in OZONE b. Obtain 30% decrease in OZONE .

c. Using a .0995 capital recovery factor which is based on an interest rate of 9.25% and a 30 year payback.

Table 35

Average Annual[c] Household Benefits (dollars)
Demand Method, Household Level Data
OZONE

	A	B	C	D	
West Bay					
Suburban	8. 76[a]	0.60	8.36	60.40	589.74
	6. 47[b]	0.46	6.17	46.47	435.37
Urban		.19			
		.13			
East **Bay**					
Suburban	d	3.68	211.74	57.11	
		2.69	156.21	42.19	
'Jrban		0.70			
		0.s4			

a. Avoid 30% increase in OZONE b. Obtain 30% decrease in OZONE

c. Using a .0995 capital recovery factor which is based on an interest rate of 9.25% and a 30 year payback.

d. None in sample

Table 36

Average Annual[c] Benefits Per Household (dollars)
Demand Method, City Level Data
OZONE

	A	B	C	D	E
West Bay					
Suburban	7.62[a]	0.47	7.46	68.57	449.33
	5.72[b]	0.34	5.60	51.43	337.10
Urban		0.17			
		0.12			
East Bay					
Suburban	1.71	2.31	153.15	54.28	
	1.29	1.73	114.87	40.71	
Urban		0.87			
		0.65			

a. Avoid 30% increase in OZONE b. Obtain 30% decrease in OZONE

c. Using a .0995 capital recovery factor which is based on an interest rate of 9.25% and a 30 year payback.

which resulted. Note that the average benefit measures obtained at the city level are somewhat smaller than those at the household level.

6.3.3 Estimates of Total Benefits

We multiplied the average household benefits in Tables 33-36 by population data in Table 16 to estimate total benefits. Total benefits were estimated 'from the property value equation directly for PS12 and OZONE (using the tract level data) and from the demand method for OZONE (using socioeconomic information at the city and household levels). Tables 37 and 38 show the results. Similar to average household benefits, greater benefits are estimated for avoiding worse air quality than for obtaining better air quality.

6.3.4 Comparisons to the Los Angeles Study

The benefit measurement results of our study are not directly comparable to those in the Los Angeles study the for following reasons. First, the pollution measures of importance are different in the two areas; air quality in Los Angeles is generally much worse than in the Bay Area except for the Bay's worst air quality area. Second, the air quality categories defined in the Los-Angeles study (poor, fair, and good) are pertinent only to Los Angeles. Since each category in the Los Angeles study differed from the adjacent category by about 30%, we used a 30% change as a unit of comparison. Finally, the direct property value benefit measures are not very comparable since our estimate is based on a logarithmic model whereas theirs is based on a linear model; the log-log model results in a smaller estimate than a linear model would.

Below we give a comparison of annual benefits for a 30% improvement from the two studies:

	SF Area E Average Household (OZONE)	LA Average Household (NO_2)	LA Average Household (TSP)
Property value change	$172	$1401	$620
City level, Multiple-step log-log model	$337	$540	$593

Using the multiple-step method with the city level data, the measures obtained in the two studies are of similar magnitude.

Table 37

, . . . Comparison of Benefits[a], Obtain 30% decrease
($1,000)

A. PSI2, property value change, tract data

	A	B	C		E	
West Bay						
Suburban	181.4	4,188.0	8,024.7	19,438.0	84,927.9	
Urban		85.8				
East Bay						
Suburban	147.9	1,526.8	9,354.6	12,8"54.9		
Urban		1,309.7				
TOTAL	329.3	7,110.3	17,379.3	32,292.9	84 927.9	
GRAND TOTA						142,039.7

B. Ozone, property value change, tract data

West Bay						
Suburban	98.3	203.9	216.5	7,321.6	51 ,981.2	
Urban		25.7				
East Bay						
Suburban	10.8	177.7	9,905.0	4,698.2		
Urban		86.4				
TOTAL	109.1	493.7	10,121.5	12,019.8	51 ,981.2	
GRAND TOTA						74,725.3

C. Ozone, 3-step, household data

West Bay						
Suburban	135.6	71.0	321.0	10,475.3	131 ,331.5	
Urban		54.0				
East Bay						
Suburban	--	398.4	23,131.9	6,606.8		
Urban		93.0				
TOTAL	135.6	616.4	23,452.9	17,082	131 ,331.5	
GRAND TOTA						172,618.5

Table 37 (continued)

D. Ozone, 3-step, city data

West Bay Suburban	118.4	52.5	291.4	11,593.4	101,687.9	
Urban		34.3				
East Bay Suburban	14.6	256.2	15,926.5	6,373.5		
Urban		112.3				
TOTAL	133.0	455.3	16,217.9	17,966.9	101,687.9	
GRAND TOTA						136,461

[a]Using a .0995 capital recovery factor, average benefits in Tables 33-36, and 1970 household population in Table 16.

Table 38

Comparison of Benefits,[a] Avoid 30% Increase
($1,000)

A. PSI2, property value change, tract data

	A		C	D	E	
Weet Bay						
Suburban	592.5	13,787.5	8,024.6	63,248.6	258,313.2	
Urban		12,683.6				
East Bay						
Suburban	488.3	5,044.0	30,144.8	41,328.8		
Urban		4,326.7				
TOTAL	1,080.0	22,054.3	38,139.4	104,577.4	258,313.2	
GRAND TOTAL						424,165.1

B. Ozone, property value change, tract data

West Bey						
Suburban	322.0	673.5	716.5	23,863.1	162,685.5	
Urban		85.8				
East Bay						
Suburban	37.6	589.4	31,968.1	29,641.5		
Urban		288.5				
TOTAL	359.6	1,637.2	32,684.6	53,304.6	162,685.5	
GRAND TOTAL						250,671.5

C. Ozone, 3-step, household data

West Bay						
Suburban	181.3	92.7	435.0	13,615.4	177,898.0	
Urban		54.4				
East Bay						
Suburban		544.9	29,357.3	8,943.2		
Urban		120.9				
TOTAL	181.3	812.9	29,792,3	22,558.6	177,898.0	
GRAND TOTAL						231,243.1

Table 38 (continued)

D. Ozone, 3-seep, city data

West Bay						
Suburban	159.8	72.6	388.2	15,457.1	135,542.6	
Urban	. . . .	1.9				
Ease Bay						
Suburban	19.0	342.1	21,233.9	8,500.0		
Urban		112.3				
TOTAL	178.8	528.9	21,622.1	23,957.1	135,542.6	
GRAND TOTA						181,829.5

• Using a .0995 capital recovery factor, ● verage benefits in Tables 33-36. and 1978 household population in Table 16.

SECTION 7

SURVEY AND CONTINGENT VALUATION BENEFITS

7.1 PURPOSE OF SURVEY

Similar to the Los Angeles study (1979), we also used a survey approach (frequently termed "contingent valuation") to estimate willingness to pay for air quality. The drawback of measurements obtained from a survey, as the Los Angeles study discussed, is that there are several types of biases associated with survey studies. Nevertheless, estimates based on a survey provide a check on results obtained from a property value study and conversely.

Willingness to pay for air quality improvements is based on perceptions of air quality which are determined by both visibility and health. Health and visibility may not be equally affected by air quality changes and may not be of equal importance in affecting behavior. Thus, to predict willingness to pay for air quality improvements, we need to obtain separate values for health changes and visibility changes. In contrast to the property value method, a survey can be designed so that willingness to pay values are obtained separately for visibility and health effects. Another advantage of the survey is that we are able to test the correlation of perceptions of visibility with physical pollution measures and find which pollution measures are most indicative of perceptions.

Since the method of payment may affect survey responses (vehicle bias), willingness to pay questions may be asked on the survey in several forms as a consistency check. In comparison, the property values method limits willingness to pay to only one vehicle (house payments) which is complicated by capitalization and tax effects.

In addition to the general purpose of obtaining benefit estimates from another source, the survey implemented here has several purposes having to do with testing economic hypotheses. First, we want to be able to test whether willingness to pay is additive in health and visibility; that is, given a total willingness to pay for a change in both health and visibility, is it equal, more, or less than the sum of values for health and visibility taken separately? Second, we consider the relationship between two alternative measures of benefits: for avoiding worse air quality (equivalent variation) and for obtaining better air quality (compensating variation).

7.2 DESIGN AND EXECUTION OF SURVEY

Following the sample design given in section 5, the survey was administered in areas with varying air quality and socioeconomic characteristics in both East Bay and West Bay, urban and suburban locations. Each person in each area responded to the same set of questions. The air quality areas were defined as described in section 3. Below we briefly describe the survey instrument used.

7.2.1 Outline of Survey Questions

Appendix C gives the full questionnaire. Here we outline major areas of the survey.

Questions 1-5

The respondent's attention is drawn to the problem of air quality and general opinions about air quality in the city of residence are obtained.

Questions 6, 7

Using photographs, the respondent is first informed about three levels of visual quality (poor, moderate, and clear). The respondent then assesses air quality in his or her city with respect to the visual qualities shown in the pictures. The respondent then rates the number of days per season in the city where he or she resides when visual range is at the three levels show.

Questions 8-11, 41, 45

These are questions regarding the respondent's daily activities and perceptions of visibility at the place of work.

Questions 12-19

These questions deal with health effects and air quality. The respondent first focuses on chronic and acute diseases and symptoms which might be associated with air quality. For each type of symptom, the respondent tells whether it occurs , its frequency and its severity.

Questions 20-22

These questions deal with smoking habits.

Questions 23-25

The respondent is first informed about the EPA's PSI rating of air quality in terms of health; this serves to introduce concepts used in the willingness to pay questions. Using the index, polluted days are rated as moderate, unhealthy, very unhealthy, or hazardous. Table 39 shows the description of health effects for each type of day given to respondents.

Table 39

Information Given to Respondents,
Health Effects Related to Air Quality

Level of Air Quality	Health Effects	Likelihood of Effects and Limitations
Good	No health effects	None
Moderate	Eye irritation	Affects few persons
Unhealthful	Eye irritation Breathing problems	Affects some persons Persons with lung or heart disease should reduce physical activity
Very Unhealthful	Eye irritation Breathing problems Coughing Headaches Reduced alertness	Affects most persons Children, elderly, and persons with lung or heart disease should stay indoors and reduce physical activity
Hazardous	Eye irritation Breathing problems Coughing Headaches Reduced alertness Nausea Possible premature death for ill	Affects almost everyone Children, elderly and persons with lung or heart disease should stay indoors and avoid physical activity. General population should avoid outdoor activity.

Next, the respondent is asked questions to determine whether the respondent believes that there is some personal risk of illness on days with poor health ratings. The respondent associates with each degree of severity of illness (mild, restrictive, severely restrictive) the type of polluted day on which it would first appear.

Question 26

This is the question dealing with willingness to pay; it asks willingness to pay both to obtain better air quality and to avoid worse air quality. Willingness to pay is asked in terms of a monthly bill to the Bay Area Air Quality Management District which all residents would pay to affect air quality in the whole Bay Area.

Table 40 shows the information which was given to respondents to explain the air quality in each area. As Table 40 shows, two dimensions are used to describe air quality in these areas: visual quality (corresponding to the photographs) and health quality (described using the PSI index categorization of days). Each dimension is described in terms of the number of days at each quality level. To obtain the maximum distinction among areas by the respondent, the order of questioning is from the respondent's air quality to that of the worst area (Area E), then to that of the best area (Area A), and then the intermediate areas (D,B,C). Finally, the respondent is asked about changing to an unnamed area (Area F) with air quality which would be much worse than any levels presently occurring in the Bay region.

Question 27

A plan is described for vehicle inspection and maintenance for pollution controls devices for passenger cars; the description included the program cost and effect on automobile emissions. Respondents were then asked whether they favored the plan and reasons for support or opposition.

Questions 28-40

These questions dealt with characteristics of the respondent's current house and location.

Questions 42-44

These questions provide an alternative method of obtaining willingness to pay responses than the direct question in Question 26 above. Here, the question is asked in terms of willingness to pay more (or less) for a house with more (or less) desirable characteristics compared to the respondent's current house.

The respondent is given a set of nine cards. Each card contains a description (both in words and pictorially) of four house/location characteristics: number of bedrooms, air quality, traffic, and travel time to work. Each of these characteristics has three possible levels as follows:

Table 40

Information Given to Respondents,

Definition of Air Quality Areas

	Area A	Area B	Area C	Area D	Area E	Area F
Visibility						
Non-Polluted Days	330	265	330	265	265	205
Moderate Days	20	70	20	70	70	100
Poor Days	15	30	15	30	30	60
Health						
Good Days	294	294	232	232	191	161
Moderate Days	70	70	130	130	150	140
Unhealthful Days	1	1	3	3	20	50
Very Unhealthful Days	0	0	0	0	4	12
Hazardous Days	0	0	0	0	0	2

- bedrooms--one more, same, one less than present number
- air quality--30, 60, or 90 days more of excellent quality
  neighborhood traffic--light, medium, heavy
  commute time to work--less than 15 minutes, 15-30 minutes, more than 30 minutes. (The permutation of the levels of the characteristics on the cards was chosen according to a fractional factorial design.)

The respondent is asked to rank the cards from best to worst using a sort procedure as follows. The respondent compares each card with his or her present house and sorts the cards in three piles according whether the card represents a better, same quality, or worse house. Then within each pile the respondent ranks the cards from most to least preferred.

For each better house than the respondent's, the respondent is asked how much more he or she would pay as a monthly payment to obtain it. For each worse house, the respondent is asked whether there is a lower monthly payment they would accept to induce them to live there. These willingness to pay values provide a cardinal ranking of the cards. The responses to these questions provide an alternative source of willingness to pay data that relates more closely the property value study; it deals with comparison of house characteristics where air quality is included as one characteristic. (The scope of the study did not allow us to analyze the results of these questions.)

Questions 46-54

These questions pertain to socioeconomic information (income, education, number of family members in various age groups, present occupation, race and sex).

7.2.2 Photograph Preparation

Because we sampled respondents from the whole Bay Area, we needed pictures which would represent familiar scenes for all areas. We used photographs representative of three typical scenes. One is of the Golden Gate Bridge but could represent any scenic coastal area. Another is a very urban scene (San Francisco, Market St.). The last is a typical suburban scene (taken in Palo Alto) with single family dwellings in the foreground and foothills in the background. Respondents were shown pictures of these three scenes under three visual quality conditions: poor, moderate, and clear.

To make the picture sets, we first obtained actual photographs of scenes for a clear day, a moderate day, and a poor day.[15] The usual situation in the Bay for polluted days is that the polluted layer is over San Francisco early in the morning and moves southward toward San Jose as the day progresses with maximal apparent pollution occurring on the peninsula in the afternoon. Thus, since the photographs were not taken under quite the same conditions (time of day and scene varied slightly), we used a combination of artist and camera techniques to produce final photos which were uniform in the light conditions and scene.

The clear scene was first blown up to 8 1/2 x 11. Using airbrushing, a transparent overlay was made to match the color and optical density of the actual photograph of polluted conditions.[16] The overlayed clear scene was then used to make a new negative.

7.2.3 Comparison of the Survey Instrument to the Los Angeles Study

The key similarity of the two survey instruments is the direct asking of willingness to pay to improve the air. However, the Los Angeles study was concerned with testing for several effects which we did not do because of questionnaire length. Some of the differences between the two survey instruments are discussed briefly below.

7.2.3.1 Bidding Technique--

The Los Angeles study used an iterative bidding technique in which a starting bid was given and increased until the respondent was unwilling to pay more. The effect of different starting bids on responses was tested for and found not be significant.

We encountered another type of bias associated with bidding, that is interviewer bias. Interviewers were not uniform in the way that they presented questions, e.g., some interviewers may be more aggressive in obtaining bids than others. To avoid effects of interviewer bias, we devised a way of obtaining bids which required less interaction between the respondent and the interviewer. We showed the respondents a list of dollar amounts ranging from $0 to "more than $100" and asked them what they would pay; the amounts listed were used to give respondents some ideas but they could bid any dollar amount they wished. This technique is less leading than the iterative bidding technique and is thus less subject to interviewer differences.

7.2.3.2 Vehicle Bias--

The Los Angeles study tested for vehicle bias by asking willingness to pay in two ways: an increase in an electric bill and an unspecified lump sum payment. In the San Francisco Bay area, the utility charge was not realistic since electricity production is not a major contributor to air pollution. The two most realistic ways to pay for air quality improvement were felt to be: 1) a tax to be paid to the Bay Area Air Quality Management Control District; 2) increased house payments for living in a cleaner area. These were the two vehicles used on our survey. In addition, we asked about willingness to support a vehicle maintenance/inspection program as another of tradeoff between money payments and air quality changes.

7.2.3.3 Separability of Bids and Sequencing--

In the survey instrument for the Los Angeles study, respondents were asked about bids for improvements from their existing air quality to air quality in another areas as depicted by photographs. For a given improvement level , each respondent was requested to bid for improving air quality in terms of aesthetics only, then in terms of aesthetics plus acute health effects, then aesthetics, plus acute and chronic health effects including life shortening. Analysis of the results assumed strict additivity of bids for each air quality effect and resulted in a separate value for aesthetics, acute, and chronic health effects.

In our study, instead of asking respondents to alter their bids hypothetically to include or exclude different air quality effects for the same pictured improvement level, we obtained bids for alternative air quality areas; some of these changes involved health only, some of them involved visibility only, and some involved changes in both health and visibility. This way of obtaining the information about separate health and visibility values was less hypothetical. Then, in the analysis, we did not assume additivity of health and visibility bids; instead we tested for separability of the total bid into bids for health and visibility.

The Los Angeles study tested for the effect of sequencing (whether the order of bidding for aesthetics or health effects had an effect on values obtained for health and visibility); the report supported the hypothesis of no effect. Thus, we did not test for effect of sequencing. We used a fixed order (worst change, best change, intermediate change) of questioning for all respondents; this order maximized the respondent's perception of differences in air quality levels. Whether this order put health changes, visibility changes, or both changes first for a particular respondent depended on the area where the respondent lived.

7.2.3.4 Activities and Substitution--

The Los Angeles study was concerned with indoor and outdoor activities and how substitution among these activities might be affected by air pollution. This is another source of information regarding values. However, since we had to limit questionnaire length, we did not investigate substitution effects.

7.2.3.5 Description of Health and Visibility and Effect of Information--

Air quality in the Los Angeles study was described by photographs representing average conditions for air quality areas (A,B,C). The Los Angeles study presented a very brief description of health effects associated with the pollution levels illustrated in their photographs. Some respondents were sent a detailed health pamphlet. The Los Angeles study tested for the effect of this health information on survey responses.

In our study, pictures were only used to define the three levels of visual quality ("clear," "moderate," and "poor" days); these didnot represent air quality in any area. Information on number of days at each level of visual quality was given to respondents for their area and for other areas involved in air quality changes. Information about health effects was presented during the interview and was not tied to the photographs. This health information was more detailed than that fiven during the Los Angeles interview but not as detailed as the Los Angeles pamphlet. We tried to be comprehensive but to make information as accessible as possible to respondents.

7.2.3.6 Effect of Time of Clean-up--

The Los Angeles study tested for whether the time of completion of air quality improvement made a difference in bids; the hypothesis of no effect was not rejected. Here, we did not specify a time of clean up but implied that the change would occur in the near future.

7.2.4 Execution of the Survey

The survey instrument was developed after extensive pretesting by SRI to make sure that questions had information content (i.e., there was variation in responses) and were understandable. Then, the Public Sector, a private firm in San Francisco specializing in fielding surveys, was selected to carry out the survey. Tracts to be surveyed were selected according to the design given in section 4. Three of the tracts selected according to our original sample design proved to be unsuitable. One tract was eliminated because it was the only one of its type. We substituted tracts of the same type (air quality, socioeconomic, and geographic type) for the other two tracts.

The Public Sector developed the method of house sampling within each tract. Ten respondents were chosen from each tract by the following procedure. A random starting point was chosen in the tract; the ten respondents were chosen in accord with ten vectors of random length and random orientation drawn from the starting point. For comparability with the property value study, only homeowners were included in the survey. (Our sample size was too limited to test for differences in values between homeowners and nonhomeowners.) Standard procedures were used to assure the appropriate male/female ratio; weekends and evenings were used for surveying work to ensure the correct distribution. Standard call-back procedures were used if the respondents initially selected were not available.

Table 41 shows the number of respondents in each area and the proportion of households in each air quality area for the sample and for the population as a whole. Certainly less reliance can be placed on estimates obtained from areas with small sample sizes, e.g., areas A and C. Due to a limited survey budget, the number of respondents for each air quality area is perhaps too small to represent each air quality area adequately. For comparison to survey responses, Table 42 shows the average income for each area.

7.3 ANALYSES OF SURVEY RESPONSES

The survey was analyzed in two ways. Responses for willingness to pay and certain categorical responses (e.g., opinions about air quality) were averaged by area (West Bay or East Bay, urban or suburban, and air quality type); results are presented below. This type of analysis suggests some hypotheses about air quality values but does not yield benefit functions.

Table 41

NUMBER OF RESPONDENTS BY AREA

	Air Quality Type					
	A	B	c	D	E	All
West Bay						
Suburban	10	40	21	50	60	
Urban		30				
East Bay						
Suburban		60	50	51		
Urban		40				
All	10	170	71	101	60	412
Proportion in Sample	.02	.41	.17	.25	.15	
Proportion in Population	.02	.46	.11	.23	.18	

Table 42

AVERAGE INCOME BY AREA ($1000)

	A	B	c	D	E
West Bay					
Suburban	34	29	35	26	27
Urban		25			
East Bay					
Suburban		23	29	25	
Urban		18			
Average	34	24	31	25	27

A more complex analysis was used to obtain the benefit functions reported in section 7.4.

7.3.1 Air Quality Perception Responses

Is air quality in your city generally poor, fair, good, or excellent?

This" question does not differentiate between visual and health quality; later questions do focus on visual quality. Table 43 shows the percent responding "good" or "excellent" for each area. Area A (West Bay suburban) had the greatest percent of "good" and "excellent" responses and area E (West Bay suburban) had the least percent "good" or "excellent" responses. Note that area B, classified as having worse visibility than C but better health, has a lower percent responding "good" or "excellent" than area C (West Bay suburban). The results of this question indicate that physical measures used to classify air quality are in fact correlated with perceptions of air quality.

Note also that the urban areas, with better ozone and PS12 values than their suburban counterpart, have a lower percent "good" or "excellent" response than their suburban counterparts. The East Bay shows a lower percent rating "good" or "excellent" in each category compared to the West Bay and ozone and PS12 are higher in the East Bay. These results suggest that available physical air quality data used to define air quality areas are not sufficient to explain differences in perceptions of good or excellent quality.

Does air quality in your area need improvement?

Table 44 shows the percent of respondents answering that air quality needs improvement. Again, the responses for the urban areas compared to their suburban counterparts indicates perception of a worse problem. The lowest percent (50%) believing that improvement was needed was obtained in the cleanest area (area A); note that even in the cleanest area, a significant number (50%) of respondents desire improvements. The highest percent believing that improvement is needed (85%) was obtained in area E, the worst air quality area. Thus, the desire for improvement is correlated with air quality measures and perception of quality. The East Bay areas show a higher percent desiring improvement compared to the same categories in the West Bay.

Were most unfoggy days in your city closest to clear, moderate, or poor?

This more specific question about visual quality was answered using the photographs to define visual quality levels. Table 45 shows the percent responding that days in their area were closest to nonpolluted.

90% of the residents of area A thought that the days were mostly close to clear while only 16% of area E residents thought that most days were

Table 43

PERCENT RATING AIR QUALITY GENERALLY GOOD OR EXCELLENT

	Air Quality Type					
	A	B	C	D	E	All
West Bay						
Suburban	90	82	90	62	22	
Urban		70				
East Bay						
Suburban		66	42	49		
Urban		50				
Average	90	67	56	55	22	56

Table 44

PERCENT RATING AIR QUALITY AS NEEDING IMPROVEMENT

	A	B	C	D	E	All
West Bay						
Suburban	50	35	52	58	85	
Urban		40				
East Bay						
Suburban		53	68	61		
Urban		77				
Average	50	52	63	59	85	61

Table 45

PERCENT RATING DAYS CLOSEST TO CLEAR

	A	B	C	D	E	All
West Bay						
Suburban	90	70	76	32	17	
Urban		33				
East Bay						
Suburban		42	40	25		
Urban		47				
Average	90	48	50	29	17	40

Table 46

PERCENT RATING DAYS CLOSEST TO MODERATE

	A	B	C	D	E	All
West Bay						
Suburban	10	30	24	66	75	
Urban		60				
East Bay						
Suburban		58	60	71		
Urban		52				
Average	10	50	49	68	75	57

closest to clear. East Bay suburban residents thought that a lower percent of days were closest to clear compared to the same categories in the West Bay. In the urban East Bay, a higher percent thought that most days were closest to clear compared to the West Bay urban area.

Table 46 gives the summary of responses for the question whether most days were closest to moderate. This follows a similar pattern to the above. Area E'had the highest percent (9%) of people who thought that visibility was closest to poor.

Again, the differences in responses for the areas indicates that the two visibility categories we defined (based on limited airport data) are not sufficient to categorize visual quality in the Bay Area.

The Average Number of Not Polluted, Moderate, and Poor Visibility Days per Year

This question was answered by giving the number of days of each type for a typical month for each season of the year; this breakdown made recall easier. For each response, we cumulated "not polluted", "moderate", and "poor" days over the four seasons; the survey responses were multiplied by three to give total days per year. Tables 47-49 give the results averaged by area.

The responses show a pattern similar to the other perception questions. Areas A and C (the best visibility areas) reported the highest average good days per year, Areas B West Bay urban, B East Bay, and D East and West Bay all reported similar values for numbers of good and moderate days. Area B West Bay suburban had considerably more good days than the other B areas. Area E had fewer good days and more moderate and poor days than the other areas designated as having poor visibility.

Again, the responses indicate that, although our physical measures and air quality categories and physical measures are certainly correlated with perceptions, there are finer distinctions which could be made in categorizing areas.

7.3.2 Correlation of Perception Questions

Table 50 gives the simple correlation coefficients for responses for Questions 3, 6, and 7. Questions 6 and 7 deal with visual quality only and Question 3 is a more general question about quality. Perceptions about the number of good days (Question 7) and the categorization of days as closest to clear (Question 6) are highly correlated. The categorization of air quality as "generally good or excellent" was not as highly correlated with the other two questions. The implication might be drawn that more than visual perceptions are involved in rating general air quality.

Perceptions are also correlated with physical measures. Table 50 also gives the correlation of responses of these three questions to physical measures. The highest correlation (negative) for the number of good days was with PCTVIS (percent of poor visibility days) and AVENO2 (average NO_2).

Table 47

AVERAGE NUMBER OF DAYS PER YEAR RATED NOT VISUALLY POLLUTED

	A	B	C	D	E	All
West Bay						
Suburban	268	225	247	149	122	
Urban		163				
East Bay						
Suburban		168	193	154		
Urban		163				
Average	26a	179	209	152	122	171

Table 48

AVERAGE NUMBER OF DAYS PER YEAR RATED AS MODERATE VISIBILITY

	A	B	C	D	E	All
West Bay						
Suburban	66	99	a7	121	147	
Urban		119				
East Bay						
Suburban		129	103	137		
Urban		114				
Average	66	117	9a'	129	147	120

Table 49

AVERAGE NUMBER OF DAYS RATED AS POOR VISIBILITY DAYS PER YEAR

	A	B	C	D	E	All
West Bay						
Suburban	25	35	23	69	90	
Urban		77				
East Bay						
Suburban		38	46	68		
Urban		72				
Average	25	52	39	69	90	59

Table SO

CORRELATION COEFFICIENTS FOR PERCEPTION QUESTIONS

A. Correlation Between Perceptions and Physical Measures[d]

	TSPMN	COHI	PCTVIS	PSI2	OZONE	AVENO2
Q7GooD[a]	-.224	-.186	-.281	-.226	-.118	.-.283
Q3G[b]	-.278	-.215	-.142	-.307	-.337	-.274
Q6C[c]	-.251	-.160	-.208	-.238	-.232	-.258

B. Correlation Between Perception Questions

	03G	Q6C
Q7GooD	.385	.605
Q3G	1	.424

[a] Q7GooD - Number of visually nonpolluted days

[b] Q3G-Air quality is generally good or excellent

[c] Q6C - Most days were closest to clear

[d] These are defined in Chapter 3.

The highest correlation (negative) for the rating of days as mostly clear was with average NO_2. The general rating of air quality was most correlated with OZONE.

7.3.3 Health Related Questions

In Question 15, we asked respondents whether they were more likely to experience health-effects on smoggy days. Aside from the ambiguity of the term "smoggy", the responses shown in Table 51 do not indicate that a majority of respondents believe they experience health effects on days with smog. High proportions of residents in the cleanest area, the dirtiest area, and the urban area do associate health effects with smog.

We defined a health index from Questions 14 A, B, and C dealing with occurrence, severity, and frequency of certain symptoms which might be associated with air pollution. The health index was calculated as follows:

$$HI = \text{sum over symptoms of } (S1 \times SV \times FI).$$

S1 is a symptom index taking on the following values: O if the symptom does not occur, 2 for nausea or headache, 1.5 for nose/throat/eye irritation, coughing, sneezing, 4 for chest pain or shortness of breath.

SV is a severity index taking on the following values: .5 for mild, 1 for moderate, 2 for severe.

FI is a frequency index taking of the following values: 10 for seldom, 50 for now and then, and 200 for frequent.

The greater the health index, the greater the problems which might be associated with air pollution. The range of this index was from O to over 11,000.

Table 52 gives the average health index values by area. The most striking pattern is to be seen in the West Bay suburban area; the health index increases as air quality goes from A to E suggesting that there is in fact some correlation between air pollution and health effects.

We also defined a risk index which is intended to show whether the respondent believes himself or herself to be at risk on days that the EPA defines as being of poor health quality according to the PSI index. The index is calculated as follows:

$$\begin{aligned} RI = \; & .5 \text{ (Mild Restriction Risk Index)} \\ & + 1 \text{ (Moderate Restriction Risk Index)} \\ & + 2 \text{ (Severe Restriction Risk Index)} \end{aligned}$$

where the restriction for mild, moderate, or severe takes on the following values:

Table 51

PERCENT RATING HEALTH EFFECTS AS MORE LIKELY ON SMOGGY DAYS

	A	B	C	D	E	All
West Bay						
Suburban	50	25	24	48	57	
Urban		57				
East Bay						
Suburban		32	48	39		
Urban		48				
Average	50	38	40	44	57	43

Table 52

AVERAGE HEALTH INDEX BY AREA

	A	B	C	D	E	All
West Bay						
Suburban	212	219	217	318	508	
Urban		251				
East Bay						
Suburban		315	452	385		
Urban		547				
Average	212	336	382	352	508	370

Restriction index value:

Restriction (mild, moderate, severe)
occurs on:

All days or on moderate days	4
Unhealthy-days	3
Very unhealthy days	2
Hazardous days	1
No type of day or no idea	0

For example, a person who believes that mild restriction of activities would be personally experienced on unhealthy days, moderate restricted activity would occur on hazardous days, and severe restriction would never be experienced would have a risk index of 2.5. A person who believed the PSI index definitions that mild restriction would be experienced on moderate days, moderate restriction would occur on very unhealthy days, and severe restriction would occur on hazardous days would have an index value of 5.5.

A risk index value much lower than 5.5 would indicate that a person does not associate much personal health risk with the PSI index while a value greater than 5.5 indicates that a person believes himself or herself to be at greater risk than the PSI index describes. Only about 30% of the persons sampled had a risk index of 5.5 or greater.

Table 53 gives the risk index (RI) by area. Note that except for Area C East Bay, none of the averages approached 5.5. Persons in area B (West Bay) have the least belief in personal risk. Otherwise, the average risk indices by area are quite similar.

7.3.4 Vehicle Maintenance/Inspection

Table 54 gives the percent in favor of the vehicle maintenance and inspection plan described on the survey. The plan was described as follows.

All car owners would be required to take their car to an inspection station once a year to test pollution control equipment for proper operation. It is estimated that the test would cost $11 and repairs would average about $32. Regardless, car owners would not be required to pay more than $50 for repair for a total bill of no more than $61. The result of the program would be a 15% reduction in automobile emissions.

For the area as a whole, 62.1 percent of the respondents favored the plan (the plan passed in an election which occurred after the survey). The highest income areas gave the strongest support for the program. Only areas E West Bay and D East Bay gave less than a majority support for the plan. Recall that these same areas had a majority believing that air quality needed improvement. Reasons given for opposition to the program include beliefs that the program was too expensive, impractical, or involved too much bureaucracy.

Table 53

AVERAGE RISK INDEX BY AREA

	A	B	C	D	E	All
West Bay						
Suburban	2.4	1.4	2.4	2.7	2.9	
Urban		3.1				
East Bay						
Suburban		2.1	4.4	3.0		
Urban		3.0				
Average	2.4	2.4	3.8	2.9	2.9	2.8

Table 54

PERCENT IN FAVOR OF VEHICLE MAINTENANCE/ INSPECTION PLAN

	A	B	C	D	E	All
West Bay						
Suburban	90	50	71	70	47	
Urban		67				
East Bay						
Suburban		62	76	49		
Urban		72				
Average	90	62	75	59	47	62

7.3.5 Average Willingness to Pay by Area

Responses were sorted by area and the average bid per month was computed by area for the changes in air quality described on the survey. (For comparison to willingness to pay responses, Table 55 gives the percent changes in the air quality measures; these were not given on the survey but were used in the analysis.) Table 56 gives average willingness to pay by air quality area. Below we summarize results for both "better" and "worse" changes.

The responses include bids for health changes only (A to C, B to D, D to E for "worse" changes and the reverse direction for "better" changes), bids for visibility changes only (A to B, and C to D for "worse" and the reverse for "better"), and bids for combinations of changes (A to D and C to E). The biggest decreases in air quality occur changing from area A to areas E and F; the corresponding monthly bids are also the largest. Generally, the bids increase as worse effects are avoided or as improvements increase. However, the standard deviations of the responses are large relative to the average values. Here we report trends suggested by examining the average values; formal hypothesis testing is done using regression analysis reported in the next section.

The bids for obtaining "better" health quality appear to be lower than the bids for avoiding "worse" air quality. From C to A the average bid is $11 while from A to C it is $13.75; however, the percent change from C to A is not the same as the percent change from A to C since a different base is used. From D to B the bid is $7 and from to B to D it is about $8. From E to D the bid is $3 and from D to E it is $9. Comparing "worse" and "better" situations, there seems to be less difference in the magnitude of bid for improving air quality as compared with the variation in bids to avoid the "worse" situation. This suggests that payments for improvement may reach a limiting value as the percent improvement increases.

The bid from A to C and B to D are for health quality changes only, From A to C the bid is about $12. For B to D, the bid is about $8 for the same percent change as A to C; recall that B is a lower income area than A and also has the lowest percent of respondents desiring improvement in air quality.

For visual quality only, comparisons A to B and C to D apply; a bid of $12 is obtained to avoid the change from A to B. The change from C to D represents the same percent change in visual quality according to our categorization and areas A and C have similar incomes. The bid from C to D is $8. Area D has a similar income to Area B.

Some bids represent a combination of visibility and health changes. A potential interaction effect between bids for health and bids for visibility is indicated. The bid from D to A is $10; this change is the sum of a change form D to C (bid $6) and D to B (bid $7). The willingness to pay for an improvement in both health and visibility thus may be less than the sum of the separate bids. The willingness to pay to avoid worse health and worse visibility may be greater than the sum of bids for health

Table 55

PERCENT CHANGES TN AIR QUALITY MEASURES
CORRESPONDING TO WILLINGNESS TO PAY QUESTIONS

Change From \ To	A	B	c	D	E	F
A	• •	170[a] 0[b]	o 128	170 128	170 285	340 470
B	-63 0	• •	-63 128	0 128	0 285	63 470
c	o -56	170 -56	• •	170 0	170 56	340 212
D	-63 -56	0 -56	-63 0	• •	0 68	63 150
E	-63 -74	0 -74	-63 -41	0 -41	• •	63 48

[a] Percent increase in PCTVIS; "-" denotes a change to a better air quality

[b] Percent increase in PSI2; "-" denotes a change to a better air quality

Table 56

AVERAGE MONTHLY WILLINGNESS TO PAY FOR CHANGES
BY AIR QUALITY AREA, ALL RESPONDENTS

Change from \ to	A	B	C	D	E	F	(Number of Respondents)
A	•	12.5 (17.53)[a]	13.75 (18.08)	21.11 (20.73)	38.33 (28.61)	60 (36.83)	(9)
B	5.80 (11.39)	•	6.13 (9.02)	7.70 11.02)	12.23 (16.95)	16.63 (19.19)	(145)
C	10.78 (16.27)	6.36 (1.20	•	7.98 (2.51)	14.18 (15.06)	24.39 (25.71	(64)
D	10.08 (13.94)	7.70 (12.46)	5.96 (2.56)	•	9.48 (12.77	16.46 (19.18)	(83)
E	9.35 (15.97)	6.44 9.84)	3.79 6.37)	3 (5.53)	•	13 (21.09)	43)

[a] Standard deviation in parentheses

only and bids for visibility only: from A to E the bid is $38 compared to bids for A to B ($12) and B to E ($12). Of course B is a lower income area so this accounts for some of the difference.

To indicate whether there are differences in bids by East and West Bay respondents and urban and suburban respondents, we also sorted responses by these categories. Table 57 shows the results; they are not uniform. For East Bay area D, bids are uniformly lower than for West Bay area D. In area C, bids are lower for the East Bay for the "worse" case but higher for the "better" case. For area B, East Bay suburban, bids are slightly higher overall than for the corresponding area in the West Bay. The urban East Bay had lower bids than the suburban East Bay, due in part to lower income. For area B urban, a larger bid to obtain an improvement to A was obtained than for area B suburban; other bids were about the same.

To reduce variation due to the effect of income on bids, we also sorted responses by income. Table 58 shows the average bids by air quality area where income of respondents is in the range $15-30,000. Tables 56 and 58 have similar results indicating that income may not have a large effect on bids.

There were some respondents who gave the same bid regardless of the level of air quality change. It was felt that such respondents were not really playing the bidding game. Some of these respondents gave zero bids regardless of the air quality change. Many of the respondents giving zero bids also gave comments indicating an ideological bias against being asked to pay (e.g., someone else was responsible for pollution and should pay instead). To test the effect of excluding such bidders, we formed a "select" group of respondents which excluded bidders with no variation or major inconsistencies. Table 59 shows the bids for the "select" respondents. Although, the bids are larger in Table 59 compared to Table 56 in some cases, the differences in average bids are not great. In the later regression analysis, only those bids which were always zero regardless of air quality change were excluded.

In addition to the average bid, the median bid has some interest; 50% of the respondents would pay more than the median bid and 50% of the respondents would pay less than this amount. Some amount less than the median would receive majority support if voted on in an election. Table 60 shows the median bids by area. The results may be compared to the responses for the vehicle maintenance/inspection plan costing up to $61 annually ($5 monthly). Area E did not have majority support for the plan and generally had median bids less than $5 a month.

7.4 WILLINGNESS TO PAY BID CURVES

The above discussion indicated some reasons why bids from different areas may differ apart from the level of air quality change: income and other socioeconomic factors, perceptions, geographic factors, etc. To test for such effects and to separate their effects on bids, we used a

Table 57

AVERAGE MONTHLY WILLINGNESS TO PAY FOR CHANGES IN AIR QUALITY,
BY AIR QUALITY AREA, BAYSIDE, AND URBAN/SUBURBAN, ALL RESPONDENTS

East Bay - Suburban

Change From \ To	A	B	C	D	E	F	(Number of Respondents)
A	•						
B	5.42 (9.18)[a]	•	7.19 (12.26	9.60 (15.19)	13.25 (17.45)	19.47 (25.75)	(48)
C	11.09 (17.27)	6.89 (11.89)	•	7.4 (12.36)	11.07 (13.11)	19.27 (22.37)	(47)
D	6.84 (8.86)	5.32 6.45)	4.86 (9.22)	•	5.19 (5.44)	11.21 (17.86)	(38)

a Standard deviation in parentheses

Table 57 (continued)

AVERAGE MONTHLY WILLINGNESS TO PAY FOR CHANGES IN AIR QUALITY, BY AIR QUALITY AREA, BAYSIDE, AND URBAN/SUBURBAN, ALL RESPONDENTS

West Bay Suburban

Change From \ To	A	B	C	D	E	F	(Number of Respondents)
A	•	12.50 (17.52)	13.75 (18.08)	21.11 (20.73)	38.33 (28.61)	60.00 (36.83)	(9)
B	4.53 (8.27)	•	5.17 (7.82)	8.14 (11.08)	12.20 (12.97)	15.70 (17.10)	(35)
C	10.05 (14.01)	5.10 (9.55)	•	9.30 (13.07)	21.35 (17.06)	35.65 (29.40)	(20)
D	12.70 (16.60)	9.61 (15.53)	6.85 (14.75)	•	12.93 (15.69)	20.89 (19.31)	(45)
E	9.35 (15.97)	6.44 (9.84)	3.79 (6.37)	3.00 (5.53)	•	13.00 (21.09)	(43)

Table 57 (continued)

AVERAGE MONTHLY WILLINGNESS TO PAY FOR CHANGES IN AIR QUALITY,
BY AIR QUALITY AREA, BAYSIDE, AND URBAN/SUBURBAN, ALL RESPONDENTS

East Bay - Urban

Change From\To	A	B	C	D	E	F	(Number of Respondents)
B	5.07 (lo. 12)	•	6.32 (7.24)	6.26 (5.89)	8.71 (5.43)	15.84 (12.64)	(31)

West Bay – Urban

Change From\To	A	B	C	D	E	F	(Number of Respondents)
B	8.86 (17.87)	•	5.29 (4.84)	5.46 (5.07)	14.43 (26.54)	13.67 (13.92)	(28)

Table 58

AVERAGE MONTHLY WILLINGNESS TO PAY BY AREA, INCOME $15,000-30,000, ALL RESPONDENTS

Change From \ To	A	B	C	D	E	F	(Number of Respondents)
A	•	25 (0)	25 (0)	50 (0)	75 (0)	100 (0)	(1)
B	7.85 (15.59)[a]	•	8.11 (2.01)	9.44 (13.09)	12.36 (17.33)	20.45 (26.70)	(52)
C	12.64 (20.03)	7.32 (12.52)	•	7.20 (12.52)	13.80 (16.22)	25.66 (30.03)	(24)
D	10.12 (12.09)	7.62 (10.27)	6.56 (10.25)	•	10.40 (11.66)	13.61 (12.78)	(31)
E	9.37 (6.02)	6.00 (5.78)	3.37 (3.79)	2.37 (3.55)	•	11.87 (7.50)	(16)

[a] Standard deviation in parentheses

Table 59

AVERAGE MONTHLY WILLINGNESS TO PAY BY AIR QUALITY AREA, SELECT RESPONDENTS [b]

Change From \ To	A	B	C	D	E	F	(Number of Respondents)
A	•	9 (10.84)	11 (12.94)	23 (21.68)	52 (26.60)	77 (38.99)	(5)
B	6.45 (12.89)[a]	•	6.84 (9.94)	8.96 (12.21)	14.14 (16.15)	20.58 (20.95)	(104)
C	12.31 (17.02)	6.1.5 (10.14)	•	8.36 (11.98)	15.79 (14.91)	27.48 (25.19)	(48)
D	11.11 (12.55)	7.97 (10.49)	5.76 (10.62)	•	10.32 (10.85)	17.16 (14.58)	(63)
E	12.56 (18.70)	7.93 (10.82)	3.70 (5.68)	2.44 (3.91)	•	16.67 (25.08)	(27)

[a] Standard deviation in parentheses

[b] Those with preference reversals or no variation in bids were excluded.

Table 60

MEDIAN MONTHLY WILLINGNESS TO PAY BY AREA

All Respondents

Change From \ To	A	B	C	D	E	F	(Number of Respondents)
A	•	5	5	20	50	50	(9)
B	1	•	5	5	10	10	(142)
C	5	w L	•	5	10	20	(64)
D	5	n	1	•	5	10	(83)
E	5	e J	1	0	•	10	(42)

Select Respondents

Change From \ To	A	B	C	D	E	F	(Number of Respondents)
A	•	5	5	20	50	100	(5)
B	1	•	5	5	10	15	(104)
C	5	– +	•	5	10	21	(46)
D	6	m	1	•	10	15	(63)
E	10	m	2	0	•	10	(27)

regression analysis. The regression analysis also produces a benefit function which can be used to predict benefits for changes other than those directly obtained on the questionnaire. The regression analysis is based on theory of the bid curve as explained below.

7.4.1 Theory of the Bid Curve

The "bid curve" expresses willingness to pay as a function of varying changes in visibility and health; it also shifts with income and other socioeconomic characteristics. The theory underlying the bid curve relates to compensating and equivalent variation measures of benefits as derived from a consumer utility function.

The 'survey obtained two different willingness to pay measures--willingness to pay to avoid worse air quality (WTP^e) and willingness to pay to obtain better air quality (WTP^c); these are respectively equivalent and compensating measures defined from an indirect utility function as follows:

$$U(M_0 - WTP^e, Y_0, P_0) = U(M_0, Y_0 - \bar{y}, P_0) = U^1 \tag{1}$$

$$U(M_0 - WTP^c, Y_0 + \bar{y}, P_0) = U(M_0, Y_0, P_0) = U^2 \tag{2}$$

where U is the indirect utility function, M_0 is the initial level of income, Y_0 is the initial level of air quality (a "good"), and $\bar{y}$ is a change in air quality; P_0 is the price of private goods (a constant here).

As discussed in Loehman (1983), these measures may also be derived from an expenditure function $\mu(U,Y,P)$ for private goods as related to air quality Y:

$$WTP^c = \mu(U^0, Y_0, P_0) - \mu(U^0, Y_0 + \bar{y}, P_0)$$

$$= \int_{Y_0}^{Y_0+\bar{y}} - \frac{\partial\mu(U^0, y, P_0)dy}{\partial y} \tag{3}$$

$$WTP^e = \mu(U^1, Y_0 - \bar{y}, P_0) - \mu(U^1, Y_0, P_0)$$

$$= \int_{Y_0-\bar{y}}^{Y_0} - \frac{\partial\mu(U^0, y, P_0)dy}{\partial y} \tag{4}$$

The theoretical shape of the WTP^c bid curve is concave. The WTP^e bid curve is not necessarily concave but the income constraint leads one to expect it to be concave; if the marginal utility of income increases faster than the marginal utility of air quality, as income is given up to avoid air quality decreases, then the WTP^e bid curve will also be concave. The relative size relationship between WTP^e and WTP^c depends on relative sizes of second order derivatives of the expenditure function. Thus, empirical studies such as this one are needed to determine the relative sizes of the WTP^e and WTP^c measures.

Another empirical issue is whether or not the willingness to pay for health and visibility is more or less than the sum of separate value for health and visibility. Brookshire, et. al. (1979) were concerned about whether or not the ordering of questions about willingness to pay for health, visibility, and soiling would make a difference in the value assigned, in effect implying that willingness to pay for these goods jointly may not be additive over the goods considered separately.

Here we define compensating and equivalent measures over more than one good by extending the definitions above. For example, for two goods and a compensating measure:

$$U(M_o - WTP^c,\ Y_1^0 + \bar{y}_1,\ Y_2^0 + \bar{y}_2,\ P_o) = U^o \tag{5}$$

$$WTP^c = \mu(U^0,\ Y_1^0, Y_2^0, P_0) - \mu(U^0,\ Y_1^0 + \bar{y}_1,\ Y_2^0 + y_2, P_0)$$

$$= \int_P -\frac{\partial\mu}{\partial y_1}\,dy_1 - \frac{\partial\mu}{\partial y_2}\,dy_2 \tag{6}$$

where P is a path between (Y_1^0, Y_2^0), and $(Y_1^0+\bar{y}_1, Y_2^0+\bar{y}_2)$. If μ is continuously differentiable, it can be shown that Green's theorem holds so that WTP^c is well-defined. However, in general willingness to pay for changes in two goods is <u>not</u> the sum over willingness to pay for each good separately. For example, using a utility function

$$u = \ln M + B_1 \ln Y_1 + B_2 \ln Y_2 \tag{7}$$

for each good separately

$$WTP_1^c = M_o \left[1 - \left(\frac{Y_1^0}{Y_1^0 + y_1} \right)^{B_1} \right] \tag{8}$$

$$WTP_2^c = M_o \left[1 - \left(\frac{Y_2^0}{Y_2^0 + y_2} \right)^{B_2} \right] \tag{9}$$

whereas for changes in both

$$WTP^c_{1,2} = \alpha_0 \left[1 - \left(\frac{Y_1^o}{Y_1^o + y_1}\right)^{\beta_1} \left(\frac{Y_2^o}{Y_2^o + y_2}\right)^{\beta_2} \right] \tag{10}$$

$$\neq WTP^c_1 + WTP^c_2$$

7.4.2 Empirical Results

Methods of ordinary demand curve specification and measurement are well developed. However, the basis for specification and estimation of bid curves is not so well developed. The slope of the bid curve $(-\partial\mu/\partial y_i)$ has the properties of a demand function (Loehman, 1983); it is positive but declining and shifts with socioeconomic characteristics such as income. Thus, an appropriate functional form must be chosen to have these properties. Rather than specifying a functional form for utility and deriving the corresponding form for the WTP function, WTP was approximated by a translog function; this function has the appropriate marginal properties and its use is less restrictive than specifying a form for utility. (A procedure based on specifying utility was attempted but did not produce results as good as the translog approximation.) Separate estimations were made for WTP^e and WTP^c since it is not possible to pool the observations without an underlying utility theory. The form used for both was

$$WTP = \alpha(S)\ln(1+\frac{y_1}{Y_1}) + \beta(S)\ln(1+\frac{y_2}{Y_2}) + \gamma\ln(1+\frac{y_1}{Y_1})\ln(1+\frac{y_2}{Y_2}) \tag{11}$$

where S denotes socioeconomic shifters of the demand relation and $\frac{y_i}{Y_i}$ is the "percent change" from the initial air quality. The term γ allows testing for additivity of WTP over goods; if $\gamma \neq 0$ then WTP is not additive. The form specified (with no constant term) allows WTP to be zero if there is no change in either visibility or health.

7.4.2.1 Estimation of the Bid Curves

According to our theoretical model, socioeconomic variables (e.g., MKT1, URBAN, CINC) are shifters of the coefficient of visibility changes and health changes in predicting bids; to estimate the model[17], we multiply these variables by the health and visibility terms. We treat the perception variables similarly, multiplying those (HI, RI, SMKI) related to health by the health change term and that (Q7GD) related to visibility by the visibility change term. In addition, the model includes the product of health and visibility changes (PPSIVIS4) and two "correction" terms. CORR (Vis.) is the natural logarithm of the ratio of the visibility information given on the survey to the actual visibility value. CORR (Health) is the natural logarithm of the ratio of the survey health index value to actual health index value. When no correction is needed, these terms are just zero.

Since it is not known whether choice behavior is determined by perceptions of “goodness” or “badness,” models were estimated with both “good” and “bad” measures of air quality. The “good” measure was in terms of the percent change in “good” visibility days and “good” health days. For the measure of “bad” air quality, visibility was measured in terms of the percent change in number of “polluted” days and health was measured by the percent change in PS12 (fraction of “not good” days weighted by the average PSI index). (Another model used the percent change in “bad” health days not weighted by PSI; results were not appreciably different from the PSI model and are not reported.)

Using these two alternative measures of air quality, the models indicated in Table 61 were estimated. For a given willingness to pay model (“avoiding worse” or “obtaining better”), the significance level of a coefficient is fairly consistent regardless which air quality measure (“good” or “bad”) is used. However, the significance of a coefficient may be different in the WTP^e and WTP^c models. For example, smoking and the health index were not significant at the 95% level in the case of willingness to pay to obtain better air (WTP^c) but were significant in the case of willingness to pay to avoid worse air (WTP^e); heavier smokers and persons with worse health were willing to pay more to avoid worse air. Similar results were obtained for the risk index variable. These results suggest the hypothesis that health-related characteristics have more effect on willingness to pay to avoid worse air than on willingness to pay for better air.

The variable measuring perceptions of air quality (Q7GD) was significant at the 95% level in the case of WTP^c but not in the case of WTP^e; the sign of the coefficient indicates (logically) that people who thought the air was cleaner than others in their area were willing to pay less for an improvement. Income was significant at the 99% level in all models.

Of most interest is the result that the interaction term is significantly negative (99%) in the WTP^c model whereas it is positive (significant at 97%) in the WTP^e models. Thus, results indicate that people are willing to pay less for the combination of health and visibility improvements than for each separately; whereas to avoid a decrease in both they are willing to pay more for the combination than for the separate values.

As is usual for survey studies, R^2 values are not high. In spite of having more observations, R^2 for the “avoiding worse” model is higher. In the case of willingness to pay to avoid worse air quality, air quality measured as the change in “good” days gave a higher R^2. While strong conclusions are not possible, the implication might be drawn that perception of “badness” is the appropriate measure of air quality for the case of willingness to pay to improve air and perception of “goodness” is the appropriate measure for willingness to pay for avoiding worse air quality.

Table 61

WILLINGNESS TO PAY REGRESSION MODELS

Model	Obtain Better		Avoid Worse	
	WTP^c_G	WTP^c_B	WTP^e_G	WTP^e_B
VISIBILITY				
Q7GD	-10.81 (-2.02)	-4.67 (-2.05)	-8.45 (-1.19)	-2.66 (-1.33)
CINC	.00074 (3.54)	.00032 (3.55)	.00097 (3.42)	.00023 (3.84)
URBAN	-9.45 (-.91)	-2.67 (-.60)	-12.39 (-.65)	-8.38 (-1.03)
MKT 1	29.85 (3.65)	11.80 (3.43)	-6.34 (-.53)	3.79 (1.24)
HEALTH				
HI	.0050 (1.25)	.0041 (1.71)	.0095 (2.64)	.0024 (2.88)
SMKI	.0259 (1.71)	.0120 (1.36)	.065 (3.93)	.01843 (4.57)
RI	1.34 (1.64)	.7687 (1.61)	1.6888 (1.85)	.5567 (2.50)
CINC	.00066 (4.33)	.00038 (4.28)	.00052 (2.69)	.00014 (3.69)
URBAN	--	--	-30.01 (-3.15)	-3.27 (-1.38)
MKT 1	8.89 (1.48)	7.44 (2.03)	36.42 (4.55)	4.80 (2.74)
CORR (Vis.)	14.57 (3.39)	13.97 (3.27)	14.09 (2.77)	4.15 (.83)
CORR (Health)	12.03 4.23	10.51 (3.74)	23.64 (6.28)	13.99 (2.96)
VISIBILITY & HEALTH	-67.61 (-2.48)	-17.16 (-2.35)	66.57 (1.97)	5.52 (2.67)

Table 61 (continued)

Adj R*	.0601	.0756	.1649	.1580
N	571	571	800	800

WTP_G: Y_1 = %Δ Good Vis. Days
Y_2 = %Δ Good Health Days

WTP_B: Y_1 = %Δ Moderate or poor visibility days
Y_2 = %Δ PSI2

DEFINITIONS OF REGRESSION VARIABLES

Q7GD- The ratio of the respondent's perception of the number of good visibility days to the average number of good days perceived in the air quality area in which the respondent lived; a value lees than one indicates the respondent perceives the air to be worse than others in the area.

CINC- Annual income (1980) of the respondent; derived from a categorical variable.

URBAN- A *dummy* variable respondent indicating whether the respondent lives in an urban or suburban area (1 = urban).

MKT 1- A dummy variable respondent indicating whether the respondent lives in the East or West Bay (1 = west).

HI- A health index; higher values indicate worse health.

SMKI- An index of smoking; higher values indicate more smoking.

RI- An index of belief in health effects occurring on polluted days. Increasing values indicate increasing belief; a value of 5.5 indicates perfect belief in PSI index: a value of 2.5 indicates belief chat the worst health effect experienced would be moderate restriction of activity regardless of the PSI level.

CORR- Corrections needed since air quality measures defined on the survey were sometimes not the actual values for the area in which the respondent lives; zero when no correction is needed.

PSI2- A multiple of the average PSI for an area times the percent of non-healthy (moderate, unhealthful and very unhealthful) days.

PCTVIS- Percent of polluted visibility days, (days with below ten miles of visibility and humidity less than 70 percent).

NOTE: Variables under "visibility" were multiplied by the visibility measure whereas variables under "health" were multiplied by the health measure. "Visibility and health" refers to the interaction term. Values in parenthesis are c-statistics.

7.4.2.2 Evaluation of Bid Curves

The differences in coefficients obtained for the "avoiding worse" and "obtaining better" models suggest that willingness to pay for an improvement is different from willingness to pay to avoid a worse situation. The models also differ according to the air quality measure used. In order to obtain further implications from the various models, numerical evaluations are useful.

The coefficients *a(S)* and β(S) in (11) were evaluated by model for each air quality area according to its socioeconomic characteristics. The coefficients a(S) and β(S) represent the relative value of a small (eg. 1%) change in visibility and health separately. Table 62 compares coefficients across geographic areas; note that coefficients are roughly similar for a given model across areas in spite of their socioeconomic differences; thus, the bids for a given percent change in air quality as predicted to be similar across areas. Table 63 compares coefficients across models for areas B and E; note that coefficients differ for models with different measures of pollution.

Tables 64a, b compare estimated bids derived from alternative models for areas B and E for 1, 7, and 30 day changes in visibility health, and the combination. Note that all models give bid estimates of similar magnitude for a given changeein days. The effect of the interaction term (positive in the case of WTP and negative in the case of WTP^{e}) is small.

Area B is in the best health category but is in the inferior visibility category; area E is in the inferior health and worst visibility categories. A 30 day change in "moderate" health days represents a smaller percent of "bad" health days in area E than in B. On the other hand, area B has more good days so a change of 30 "good" days is a smaller percent of good days in area B than in area E. Thus, although the coefficients in Table 63 are similar, estimated bids based on the "good" measure are larger for E than for B and conversely for bids based on thee''bad" measure. Note also there is no consistent pattern as to whether WTP or WTP^{e} is bigger; the relationship depends on the model.

7.4.2.3 Conclusions

Below we present some general conclusions based on the empirical results given in Tables 61-64.

1. Willingness to pay to avoid worse air (WTP^{e}) or obtain cleaner air (WTP) are different benefit values.

2. There is a significant interaction effect such that willingness to pay for visibility and health is not additive; to obtain better air, the WTP for both is smaller than the individual sums whereas for avoiding worse air, the reverse holds. However, the magnitude of the interaction effect is small for small changes.

Table 62

COMPARISON OF COEFFICIENTS ACROSS AIR QUALITY AREAS,
WEST BAY SUBURBAN

WTP^{e}_{B}

	A	B	C	D	E
a(S)	8.95	7.80	9.18	7.11	7.34
β(S)	12.37	12.29	12.67	12.31	12.58
γ	5.52	5.52	5.52	5.52	5.52

WTP^{c}_{B}

	A	B	C	D	E
a(S)	18.01	16.41	18.33	15.45	15.77
β(S)	23.7	21.82	24.20	21.75	22.77
γ	-17.16	-17.16	-17.16	-17.16	-17.16

“B” denotes willingness to pay measured as a function of PS12 and the percent of polluted visibility days.

Table 63

COMPARISON OF RELATIVE VALUES ACROSS MODELS,
WEST BAY SUBURBAN

AREA B

	$\alpha(S)$	13(s)	Y
WTP^c_G	40.50	33.96	-67.61
WTP^e_G	13.34	63.38	66.57
WTP^c_B	16.41	21.82	-17.16
WTP^e_B	7.80	12.29	5.59

AREA E

	$\alpha(S)$	13(s)	Y
WTP^c_G	39.02	34.78	-67.61
WTP^e_G	11.40	64.30	66.57
WTP^c_B	15.77	22.77	-17.16
WTP^e_B	7.34	12.58	5.52

"G" denotes willingness to pay measured as a function of percent good visibility days and percent good health days.

"B" denotes willingness to pay measured as a function of PS12 and the percent of polluted visibility days.

WTP^e_G = Avoid loss of good days.

WTP^c_G = Obtain increase in good days.

WTP^e_B = Avoid increase in polluted days.

WTP^c_B = Obtain reduction in polluted days.

Table 64

COMPARISON OF MODEL VALUES, MONTHLY WILLINGNESS TO PAY

a. Area B, West Bay Suburban

	Visibility			Health			Combined		
	1	7 (Good Days)	30	1	7 (Good Days)	30	1	7 (Good Days)	30
WTP^{e}_{G}	.05	.34	1.43	.21	1.50	6.15	.26	1.88	8.27
WTP^{c}_{G}	.15	1.04	4.34	.11	.80	3.30	.26	1.81	6.93

	Visibility			Health			Combined		
	1	7 (Poor Days)	30	1	7 (Moderate Days)	30	1	7 (Poor Visibility/ Moderate Health)	30
WTP^{e}_{B}	.07	.53	2.05	.22	1.49	7.06	.30	2.06	9.76
WTP^{c}_{B}	.16	1.11	4.30	.39	2.55	10.69	.55	3.53	13.23

WTP^{e}_{G} = Avoid loss of good days.

WTP^{c}_{G} = Obtain increase in good days.

WTP^{e}_{B} = Avoid increase in polluted days.

WTP^{c}_{B} = Obtain reduction in polluted days.

Table 64 (continued)

b. Area E, West Bay Suburban

	Visibility			Health			Combined		
	1	7 (Good Days)	30	1	7 (Good Days)	30	1	7 (Good Days)	30
WTP^e_G	.04	.29	1.22	.33	2.31	9.37	.37	2.66	11.62
WTP^c_G	.15	1.00	4.17	.18	1.25	5.07	.33	2.19	8.19

	Visibility			Health			Combined		
	1	7 (Poor Days)	30	1	7 (Moderate Days)	30	1	7 (Poor Visibility/ Moderate Health)	30
WTP^e_B	.07	.50	1.93	.10	.71	2.91	.17	1.23	5.17
WTP^c_B	.16	1.06	4.14	.18	1.26	4.79	.34	2.26	7.98

WTP^e_G = Avoid loss of good days.

WTP^c_G = Obtain increase in good days.

WTP^e_B = Avoid increase in polluted days.

WTP^c_B = Obtain reduction in polluted days.

3. Estimated bid values differ according to the subjective measure of air quality used (perception of “goodness” or “badness”).

4. Individual characteristics in addition to income, (such as health, smoking, and perception of risk) appear to affect bids, particularly in the case of avoiding worse air quality.

Furthermore, by assumption of the functional form of the model, the value per day of visibility or health is not a constant. These conclusions confirm of earlier studies (Brookshire, et. al.) which suggest that it is not possible to define a uniform "value" for air quality which can be used in a benefit analysis for any geographic area; the value will depend on the local situation.

Although the differences in estimated willingness to pay values of alternative models are not too great when dealing with small changes, differences may be more significant for larger changes. More research is needed to determine which air quality measures are most appropriate. A data set based on a larger sample would, hopefully, produce models with higher R^2 on which stronger conclusions could be based.