An Economic Analysis of Consumer Expenditures for Safe Drinking Water: Addressing Nitrogen Risk with an Averting Cost Approach

by

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This article presents a procedure for estimating averting expenditures through the analyses of two data sources: (1) packaged water sales from 18 national supermarket chain stores in the Columbus, Ohio Metropolitan Area (COMA); and (2) treatment expenditures for both high and low service water from a local drinking water treatment facility owned and operated by the Columbus, Ohio municipality. The averting behavior results from a nitrogen advisory for drinking water for 1/3 of the COMA. The study concentrates on estimating these averting expenditures as representative of averting behavior for a market and non-market good trade-off. This article concentrates on the economic consequences of the nitrogen pollution problem as it affects households through the water they drink. It measures the private and public averting for the remedies available to address this problem.

Major findings are that consumers make significant expenditures on packaged water both inside and outside the nitrogen advisory area and the municipality also makes considerable averting expenditures. The results represent an averting behavior effect emanating through an area having experienced recent and historic nitrogen advisory events with significant implications for government and industrial strategies for identification and prevention of nitrogen contamination incidents.

Introduction

On June 13, 2000 the U.S. EPA issued the fourth nitrogen advisory for tap water for the COMA in 12 years. The advisory occurred at the City of Columbus' Dublin Road Water Treatment Plant (DRWP) and lasted five weeks. Other advisories occurred on: June 18, 1998; July 2, 1994; and May 14, 1992.

Since these stochastic nitrogen threats have irregular flows and vary considerably in terms of quantities and concentrations, controlling them has been difficult. Governments have considered many different treatment regimes involving: taxing and subsidy polices, investments in mixing facilities or reservoirs where nitrogen is diluted, costly water treatment facility upgrades that include technologies such as reverse osmosis or ion exchange, to more labor intensive actions such as increased testing and farmer education in Best Management Practices (BMP) for nitrogen reduction (Shortle and Abler, 2001; City of Columbus, 2004). These practices, however, still allow measurable economic uncertainty and risk to enter into the pollution abatement function (Bystrom et al, 2000) and only treat the problem temporarily or for a fraction of those affected (City of Des Moines, 2004).

Conceptual/Theoretical Framework

If consumers form anticipatory expectations based on past events, then they are likely to place a relatively high probability on a nitrogen advisory being issued in the month of June. As such, this raises the research question as to whether there are measurable expenditures consumers make during the month of June and other periods of the year to insure the safety of their drinking water. Known in previous work as averting or defensive expenditures, this approach is a measurement of the costs that increased pollution imposes on consumers of water. These costs are defined by O'Connor and Spash (1999) as the costs incurred or potentially incurred by households, firms and state authorities to avoid environmental damages. First, one assumes that a lower bound estimate of the willingness to pay (WTP) by residents can be estimated by placing economic values on the averting expenditures households and municipalities make to mitigate the effects of a short term pollution episode and protect the household from welfare reductions. Then this estimate of a defensive measure can be considered a lower bound value of public expenditures for the implementation of more cost efficient nitrogen control strategies, such as wetlands.

The model is applied to the nitrogen advisory incident occurring in 2000 which had both real and perceived threats to individuals through the quality of their drinking water. Packaged water sales data was acquired for the year 2002, although no advisories were issued that year. Instead, it was hypothesized that a residual effect still lingers in Columbus, Ohio from a June nitrogen advisory that took place two years prior.

The measurement of these expenditures constitutes an estimate of the substitution cost to individual victims of pollution for averting inputs. The assumption is that the quality of an individual's personal environment is a function of the quality of the collective environment plus the use of averting inputs. By measuring the value of costs incurred by individuals in their use of averting inputs, where a rational consumer will buy inputs to the point where the marginal rate of substitution is equal to the price ratio, (Harrison et al, 1983) one can impute a measurable cost incurred to make the personal environment different from that of the collective environment. By characterizing this rate of substitution and knowing the price paid for the substitute, we can infer the price that consumers would be willing to pay (WTP) for a change in their collective environment (Braden and Kolstad, 1991; Bartik, 1988; Harford, 1984, Abrahams et al, 2000).

The averting behavior analysis will focus on a residual effect from a temporary negative change in drinking water quality due to a nitrogen advisory. The analysis will be based on a linear multiple regression model, where

$$Y_{it} = \alpha + \beta_1 X_{1it} + \beta_2 X_{2it} + e_{it}\ , \qquad \text{(Eq. 1.)}$$

for $i = 1, 2, \ldots, N$ and $t = 1, 2, \ldots, T$ where i = the number of cross sectional units; t = the number of time periods; Y is the dependent variable; $X1$ and $X2$ are independent variables; and e is the error term.

Using the household production framework for a revealed preferences model, an attempt is made to estimate household behavior toward the purchase of packaged water as an averting expenditure. Households face a trade-off between low water quality, risk of illness, or some degree of disutility or costs to improve their water quality. If a trade-off is well defined, it is possible to use the model derived from the household production function to assess the benefits of a change in the considered public good.

Bartik, 1988, extends Harford (1984) and Courant and Porter (1981) analyses' of the establishment of individual risk and how consumers change their consumption behavior to maximize utility over cleanliness and a general commodity. Bartik examines how benefits of non-marginal pollution reductions can be evaluated using information on household defensive expenditures to alleviate pollution and maximize utility over the variables X, the numeraire good, and Q, the individual household's environmental quality, subject to a budget constraint. This research analysis builds on Bartik's (1988) defensive expenditures function and assumes that a household faces the following utility maximization problem,

$$\max_{X,Q} U = U(X,Q) \ s.t. \ X + D(Q,P) = Y \qquad \text{(Eq. 2.)}$$

It is assumed that Q is the quality of the individual's personal environment and directly affects utility. P is the level of pollution, D( ) is the defensive expenditure function showing the defensive expenditures needed to reach a particular personal environmental quality, Q, given an amount of P, pollution. Y is the income level and X is the numeriare good, where Eq. 2 is twice differentiable and the specification is increasing in pollution, environmental quality and defensive expenditures.

This method has recently been used for drinking water quality studies by Whitehead et al. (1998), who chose to evaluate health as it relates to the utility function and the value of time (Roach, 1989). Harrison et al. (1983) also address the health issue as they develop a case study pertaining to the benefits of cleaning up after a private company's hazardous waste contaminates a town's drinking water source. The authors' study includes measurements of averting expenditures for defensive measures, i.e. bottled water and water filtering equipment.

Taking the Lagrangian, £, of equation 2, we derive the first order condition.

$$U_Q / U_X = D_Q \qquad \text{(Eq. 3)}$$

This equates the marginal value of the personal environment to its marginal cost of keeping the environment at the current level through the purchases of Q and X, given P.

To establish the households maximum attainable utility, v, the indirect utility function is set up, V(P,Y), for a household given the exogenous variables Pollution and Income. Bartik gives us,

$$\text{v} = \text{V(P,Y)} = U(X^*, Q^*) + \lambda(\text{Y} - X^* - D(Q^*, P)), \qquad \text{(Eq. 4)}$$

where v, the households maximum attainable utility is equal to the Lagrangian of the households maximization problem when X and Q are optimally chosen as X* and Q*. Differentiating the indirect utility function with respect to P and Y, and setting the utility change to zero, this results in

$$\left.\frac{\partial Y}{\partial P}\right|_{v\cdot fixed} = -V_P / V_Y = D_P. \qquad \text{(Eq. 5)}$$

This tells us that the benefits of a reduction in pollution, D_P is equal to the level of defensive expenditures needed to reach the original level of personal environmental quality. He goes on to state, as Courant and Porter (1981) do also, that D_P does not equal the actual change in defensive expenditures since Q* changes, but that D_P is measurable if one knows the defensive expenditure function, which includes the individuals knowledge level and their indifference to risk. For this situation, P and Q*, would be stated as

$$\frac{dD}{dP} = D_p + D_Q\left(\frac{dQ^*}{dP}\right). \qquad \text{(Eq. 6)}$$

Eq. 6 can be viewed as the change in damages to the household with respect to the change in pollution equals the damages from the changes in pollution, or D_p or a health risk from not being protected, plus the damages, by way of costs, in expenditures to maintain a quality environment, or constant utility.

This study attempts to determine the expenditures made to keep the consumers' utility constant. The result will contain two values to import into this defensive expenditure function. These values are the sum of averting expenditures for the packaged water purchased by Columbus, Ohio residents during the month of June, and the averting expenditures observed in excess of average costs during the month of June for the City of Columbus, Division of Water, daily average treatment cost data.

Objectives and Sampling

This study focuses exclusively on individuals within the Columbus, Ohio Metropolitan Area and a local municipal water treatment facility that has experienced nitrogen advisories in the past. To use this approach directly, one must specify the effects of the currently supplied water quality on the household utility, must assume consumers realize that the effects of poor water quality directly affects consumers' health, and must establish the link between the good to be valued and the good that is used to avert pollution effects. These theories are used to measure the behavior of the consumers in their purchases of packaged water and the municipality in its expenditures to treat the public good, or tap water. This observed behavior by consumers and the municipality will be considered, measured and applied as averting expenditures.

The first objective of this project is to examine whether effects from a past nitrogen advisory still exists and can be measured through purchases of defensive expenditures by residents in Columbus, Ohio that have experienced a nitrogen advisory previously. The theory is that residents that have experienced a nitrogen advisory previously, would exhibit averting behaviors during that same time every year in which they had experienced the pollution event. They would alleviate this pollution event by purchasing defensive measures. Specifically, they would make purchases of packaged bottled water during the month of June, which is envisage to be the most likely time of a nitrogen nonpoint source pollution event. Essentially, institutional memory about the experience of a five-week nitrogen advisory that occurred in a portion of Columbus from June 13, 2000 to July 5, 2000 is likely to make 2002 data relevant for this estimation.

The second objective of the research is to conduct an averting expenditure analysis on the treatment costs of the municipal water treatment plant, specifically the Dublin Road Water Treatment Plant (DRWP), which experienced recent nitrogen advisory in the year 2000. An attempt will be made to identify averting expenditures that exist within the daily average treatment costs of the municipal water treatment plant. The theory is that during 2000 and every year after, the water treatment plant that experienced the nitrogen advisory, should exhibit averting and avoiding behaviors during the month of June, so as to not have a repeated nitrogen advisory issued.

The third objective is to estimate an economic value for the measurable averting expenditures from both the consumer purchases of defensive measures, namely, bottled water and the municipalities increased treatments costs of drinking water as averting and avoiding treatment expenditures. The attempt will establish an economic value as the lower bound estimate of the measurable effects a nitrogen advisory has on consumers and producers of drinking water; an effect that remains two years after the original advisory.

The packaged water sales data consisted of weekly sales of packaged water from a sample of 18 stores, within the Columbus, Ohio Metropolitan Area that included the years 2002 and 2003. Only data for the year 2002 is used in this study because after two years, it was assumed that individuals may be, “beyond the bounds of their historical experiences” (Harrison et al, 1998). The data consisted of per unit packaged water sales per item by week and it included packaged bottled water and packaged bulk water. Fill-your-own was not included in the data set due to its categorization as a produce item and the consistency and accuracy of the fill-your-own data was questionable. Even though no official nitrogen advisories were in affect during the time of the analyzed packaged water sales data, an attempt will be made to identify key variables to determine a packaged water demand function from the packaged water sales data for 2002.

The hypothesis is that water purchased during the five weeks of June involves incremental purchases of packaged water not explained by other variables. The five weeks in June was chosen because the residents of Columbus, Ohio had previously experienced two recent nitrogen advisories in the month of June, during the years 1998 and 2000. The assumption is that residents' institutional memory lead them to make purchases of packaged water during the same time as a previous nitrogen advisory.

Key Variables/Hypotheses and Specification Tests for Bottled Water Regression

The research objective of constructing relevant variables that are significant and explain variations in the dependent variable must begin with a tenable hypothesis. For this research, the DVJUNE variable, although a dummy variable, is the central research hypothesis of this study. The variable DVJUNE is used to describe the hypothesis that a cleanliness variable or June effect is observable in the data. The DVJUNE variable contains the five weeks of June, between the holidays of Memorial Day and the 4^{th} of July, that would completely portray a nitrogen advisory event. The research variable is hypothesized to be positively signed and to explain a portion of the dependent variable, TOTALOUNCESSOLD, thus making it measurable within the data sets.

The TOTALWEIGHTEDPRICE variable consists of the total weighted price per week per store, separated by bulk and bottled packaging. This variable is estimated for both data sets of packaged water scanner data for the six stores in the advisory area and 12 stores outside of the advisory area in the sample, over 52 weeks. This gives a total of 936 observations for each data set. The weighted price variable is calculated for each item sold and derived by dividing total sales of the item per week into the total sales per week. The weighted price represents the effect or magnitude of the number of each item sold each week, times its price. Relevant variables were determined through t-tests.

The sample of weekly packaged water sales data and summary statistics for the 18 stores are shown in Table 1a. and 1b. Since six of the grocery stores have their market area located within the nitrogen advisory area and twelve stores are located outside the nitrogen advisory area, it is hypothesized that this advisory location effect can be determined and will be measurable within the analysis. It is also felt that the negative press associated with the advisory may have affected more of the Columbus area residents than just those within the advisory area. This negative press is analyzed as the NEWSEVENTSBAD variable.

Smith, et al. (1988) report that bad news in the press can have a significant effect on the sales of the affected product. This theory was applied to the packaged water sales data by developing a weekly tally of the good and bad news events for the year 2002. The bad news events variable, NEWSEVENTBAD was significant at the 1% level and explained a significant portion of total variation in the dependent variable, TOTALOUNCESSOLD. This variable will be included in the model and will also be included in the economic valuation representation because of its significance in the model and its relationship to pollution control.

To estimate the economic averting expenditures for nitrogen risk in drinking water, the first step will be to estimate a demand function for households in the City of Columbus, Ohio for the sale of purchased water. Recall that we have packaged water sales data for 2002. After running several regressions, however, discrepancies appeared within some of the regression equations which could not be attributed to the independent variables. This gave rise to questions regarding separating the data into two, more distinct categories. Objective one consists of three parts, each involving an econometric test placed on the data to help determine the correct demand equation to estimate and analyze.

Separate vs. Pooled Data

The first objective was to determine if the packaged water sales data can be estimated as one demand function model including all of the packaged water data or if it will need to be split into two equations: one for bottled (convenience) purchased water; and one for bulk purchased water. The null hypothesis is expressed as, $B_i - B_j = 0$. A Chow Test using the F-statistic was used to test whether the two demand functions are identical, or whether the data will need to be split into two data sets. The Chow Test is defined as,

$$F(k, N + M - 2k) = \frac{(ESSr - ESSur)/k}{ESSur/(N + M - 2k)} \qquad \text{(Eq. 7)}$$

where k is the number of independent variables or the degrees of freedom in the numerator and N+M-2k is the number of observation running from 1 to N and 1 to M minus 2k or the degrees of freedom in denominator. The result of the estimated Chow Test between the entire packaged water data set (the restricted); and the bottle [convenience] packaged water data set and the bulk packaged water data set (the unrestricted) is, -38.276. The absolute value of $|-38.276|$ is much greater than the critical value of 1.88 at the 1% significance level. These differences are statistically significant, therefore the null hypothesis, of equal coefficients, can be rejected. One can say with 99% confidence that the packaged water data set will need to be estimated using two separate equations, the bottled (convenience) water data set and the bulk water data set.

In/Out Advisory Area

To begin the analysis, we attempted to determine statistical differences between that portion of the sample residing within Columbus, Ohio and experiencing the nitrogen advisory in the year 2000 and that portion residing outside of the advisory area. A dummy variable was used to differentiate between the stores within the Dublin Road Water Treatment Plant service area and outside of the Dublin Road Water Treatment Plant service area. It was expected that this variable would be positively correlated with the TOTALOUNCESSOLD. However, during the initial regressions, it was noticed that this variable exhibited multicollinearity and was suspected to be correlated with the fixed effect constants leading one to believe that the variable INOUTAREA should be left out of the regression model. Further examinations of this variable left little doubt that the data should be further split into other independent data sets.

The results from the two estimated Chow Tests show the absolute values of Bulk = | 414.06 | and Bottled = |405.64 | to be significantly significant at the 1% level. These results mean that the demand for bulk packaged water in the advisory area is significantly different from the demand for bulk packaged water sales outside of the advisory area and that the demand for bottled (convenience) packaged water inside the advisory area is also significantly different than the demand for bottled (convenience) packaged water sales outside of the advisory area.

Rejection of the null hypothesis is demanded and one can say with confidence that the two data sets need to be estimated with two different regressions, resulting in four different models to be estimated. These models are: bulk water in the advisory area; bulk water out of the advisory area; bottled water in the advisory area; and bottled water out of the advisory area.

Residual Cleanliness Variable or the June Effect

An effect from the impact of the nitrogen advisory itself was also estimated with a Chow test to see if research variable or cleanliness variable could be observed. The last part of objective one is to determine if a residual cleanliness effect can be observed within both the bottled and bulk packaged water data sets. This residual effect, it is hypothesized, can be measured as the consumer avoidance costs. If verified, it would suggest that even two years after a nitrogen advisory, averting behavior from the advisory can still be detected. From Table 3, regression results, one can see that the results from the research variable are positive and statistically significant within the model. These values are used to conduct the averting expenditure analyses.

Average Daily Treatment Costs as Averting Expenditures

Daily average treatment cost data was available for the years 2000 through 2003 from the Dublin Road Water Treatment Plant (DRWP), City of Columbus, Division of Water. The data is in the form of "daily average dollar value per million gallons treated" for both the low quality/service and high quality/service water. Low quality finished water is the first stage of treatment that is used by the DRWP to clean water sold for industrial uses or treated further to become high quality water, finished water for residential, consumer distribution.

After examining the daily average treatment cost data from the DRWP, it was observed that the nitrogen advisory in the year 2000 could be observed within the treatment data. However, just like the water sales data after the year 2002, it was anticipated that the effects from the nitrogen advisory would dissipate and the costs would become difficult to assign as nitrogen residual effects. The economic estimates made with the treatment cost data will be measured for the years 2000 and will work their way forward to encapsulate the residual effects of the nitrogen advisory in the years 2001 and 2002.

This research will therefore attempt to estimate this demand function for chemical to treat drinking water for the sole reason of determining if there is a measurable residual effect, the June effect, that exists within DRWP, Columbus, Ohio from past nitrogen advisories.

The Regression Analysis

The empirical method used to analyze the packaged water sales data was a Pooled Least Squares multiple regression model using cross sectional fixed effects in the software program EViews from Qualitative Mirco Software Corp. A pooling technique was used to allow for the 18 stores to be imported as cross sectional units. This permitted regression analysis for both cross-sectional or fixed effects and a generalized least squares or random effects analysis. Cross sectional weights allowed the constant to vary by store, along with any of the designated independent variables. This analysis of longitudinal data allowed the computer program to separate out the effects of time-series from the effects of the cross sectional stores, allowing an analysis of other cross-sectional effects at points in time.

Multiple regressions were run using various functional forms, but the results showed the double log and the semi-log model forms to be poor fits for the data. These forms resulted in decreased explanatory power or produced equivalent results with the same economical and theoretical significance as the linear model. The linear model was chosen because of the robustness of the model and its direct transferability to benefit-cost analysis. The multiple regression linear models specified in this study has 18 cross sections and 52 observations per cross section. The model used in this study estimates four equation models specified as: BULK WATER IN AREA, BOTTLED WATER IN AREA, BULK WATER OUT AREA, and BOTTLED WATER OUT AREA estimated using the time-series, cross-sectional regression on the four models. For each equation, as well as the pooled form of the equations, the variables and model specifications are as follows:

$$Y_{ikt} = B_0 + B_1X1_{ikt} + B_2X_{2kt} + B_3X_{3kt} + B_4D1_{4kt} + B_5D2_{5kt} \quad \text{(Eq. 8)}$$

$$+ B_6D3_{6kt} + B_7X_{7kt} + B_8X_{8kt} + B_9D4_{9kt} + B_{10}D5_{10kt}$$

where, i = (1, 2, … , 18) or 18 stores

k = (1 , … ,2) or bottled or bulk

t = (1, 2, … , 52) or 52 weeks

The specific variables corresponding to the Y and X's in Equation 4.2 are expressed as:

$TOTALOUNCES_{ikt} = f\ (TOTALWEIGHTPRICE_{ikt}, PCTINCUNDER10_{kt},$

$AVEWEEKLYMAXTEMP_{kt}, DVWINTER_{kt}, DVSUMMER_{kt}, DVFALL_{kt},$

$NEWSEVENTSBAD_{kt}, WEEKLYPRECIPITATION_{kt}, DVJUNE_{kt}, DVHOLIDAY_{kt})$

where TOTALOUNCES (total ounces of packaged water sold) is hypothesized to decrease with TOTALWEIGHTPRICE (the total weighted price of the units sold); it is hypothesized to increase with AVEWEEKLYMAXTEMP (the average weekly temperature), DVWINTER (the winter dummy variable), DVSUMMER (summer dummy variable), DVFALL (the fall dummy variable), NEWSEVENTSBAD (the tally of the bad news events from the Columbus Dispatch), WEEKLYPREC (the weekly precipitation experienced in Columbus, Ohio with readings taken from the Olentangy River Wetland Research Park, DVJUNE (the research or cleanliness variable depicting the 5 weeks of June), and DVHOLIDAY (depicting the calendar holidays experienced by households in Columbus, Ohio). Again, Table 3 depicts the regression analyses used to evaluate the four equations.

The Municipal Water Treatment Averting Costs

The second objective is to determine whether a June effect or the cleanliness variable is observed within the average treatment cost data from the City of Columbus, Division of Water, Dublin Road Water Treatment Plant (DRWP). The average cost data from the plant was in the form of "daily dollar value per million gallons treated" for both low service/quality and high service/quality finished water, for the years 2000, 2001, 2002, and 2003 (See Tables 4a and 4b). All raw water taken into the plant from the Scioto River is first treated to the low service or low quality water standard and sold for industrial uses. The second stage of treatment is the high quality water. After this additional treatment, the high service/quality water is distributed for residential and commercial consumer use.

The null hypothesis, stated as $B_j = 0$ or there are no measurable residual effects in the water treatment cost data by the Dublin Road Water Treatment Plant during the anticipated nitrogen advisory time. The data sets were initially estimated through graphs and an estimation of averages to determine if a DVJUNE effect existed. Since averting expenditures were observed through the graphs and the estimation of averages, there was enough evidence to evaluate the data through pooled least squares regression (See Table 5a). A linear model was again chosen because of its direct transferability to benefit-cost analysis. The results are based on the linear form model:

$$Y_{it} = \alpha + \beta X_{it} - \varepsilon_{it} \qquad \text{(Eq. 9)}$$

for i = 1, 2, …, N and t = 1, 2, …, T; where N is the number of years, specifically three, and T is the number of time periods, or 365 days. Both fixed effects, which allow the constant to vary, and cross sectional effects by year were applied. Regressions were run on both the low service and high service pooled treatment cost data. Of particular interest was the impact of the research variable, DVJUNE, on the dependent variable. The regression results were robust and statistically significant (see Table 5b.).

The estimates of these averting costs by a governmental municipal water treatment facility will be a large value in the economic valuation estimates for averting expenditures for nitrogen risks in drinking water. Since the cost data is only available from 2000, there is no way to know if the DVJUNE effect that was observed in 2000 is the averting behavior from the nitrogen advisory that took place in 1998, which affected the same water treatment plant, the DRWP, and the same customer service area. Therefore the amount found for the research variable within the treatment cost data will be assumed to represent the averting expenditures for a nitrogen advisory.

Total Avoidance Expenditures Analysis

The third objective of this study was to calculate the total avoidance expenditures by the residents of Columbus through their packaged water purchases made to avert a residual health risk because of a past nitrogen advisory and the averting expenditures by the municipality through the daily average treatment costs in avoidance of, or in anticipation of, a nitrogen advisory.

An attempt will be made to estimate a lower bound, a middle bound and an upper bound estimated value for the averting expenditures found within both averting data sets. The attempt will include the results from objective one: the averting expenditure results from the analysis of the research variable, DVJUNE, found within the bulk and bottled water sales data; and from objective two: the averting expenditures results from the research variable, DVJUNE, found within the daily average treatment cost data. A matrix presented in Table 6 was formed to determine which values can be applied to the economic valuation. Calculations for the economic values (See Table 6b) will be the final economic lower bound, middle bound and upper bound estimates for each averting expenditure portion of the analysis.

The Results

The results of the averting expenditure analysis are promising. They clearly indicate that there are significant relationships between packaged water purchases, drinking water treatment and averting expenditures. A lower bound estimate of $3,272 was found for the research variable, DVJUNE. This estimate is for bottled and bulk water from just the stores within the advisory area for just the research variable. A middle bound estimate of $7,281 was found, derived from bulk and bottled water data from all of the Columbus stores included in the sample. An upper bound estimate of $9,774 was found and this value also included the BADNEWSEVENTS effects that were found within the packaged water sales in Columbus, Ohio for the year 2002.

The aforementioned figures represent a residual averting behavior effect emanating from purchases of bottled water during June as a result of a nitrogen advisory that occurred two years ago in 2000. The range of values may seem small, but the sample of 18 grocery stores within the Columbus metropolitan area where the sales data sample was taken, serves only an estimated 30% of Columbus residents. It is therefore felt that the averting behavior values represent an extremely conservative estimates of the true cost or benefits that consumers would pay for a change in environmental quality. The values are extremely conservative because (1) the effects are found two years after the actual nitrogen advisory took place; (2) the sample was drawn from only one retail chain; and (3) no other averting expenditures, such as home delivery and filtering equipment, were examined.

The result of the total averting expenditure analysis for nitrogen in 2000 is $162,704. This is a lower bound estimate of the total averting expenditures from the nitrogen treatment cost data from the year 2000 for averting expenses that are directly related to the nitrogen advisory.

Dollar amounts of $314,720, $118,396 and $420,371 are the averting expenditure amounts attributable to the research variable, DVJUNE, found within the treatment cost data for the years 2000, 2001 and 2002 respectively. The sum of these amounts with a future value attached comes to $1,156,754. This amount is the value of the upper bound estimate, including the years 2000, 2001, and all of 2002's averting expenditures brought forward through future value calculation at a 3% interest rate. This upper bound amount, determined through this research, is considered the opportunity costs of not investing nitrogen NPS pollution control strategies.

Conclusions

Since this research focuses on nitrogen pollution, flows of nitrogen down the Scioto River are relevant, since it is the water source for the Dublin Road Water Treatment Plant. Data depicting the flows down the Scioto River from six USGS testing stations from the time period January, 2001 to June, 2004 are presented in Table 7. These flows are a depiction of the stochastic and uncertain levels of chemicals as they flow down the Scioto River and are hypothesized to affect the drinking water quality in Columbus, Ohio. Notice how nitrogen has been depicted along the right vertical axis and ammonia, phosphorus are along the left vertical axis, with time along the horizontal axis. Even with this unrefined graphical time-series analysis (Tables 8a and 8b), the uncertainty of nitrogen emissions is evident, reinforcing the concept of using wetlands as a nitrogen pollution decreasing input (Shortle and Horan, 2001; Braden and Kolstad, 1991).

Implications

In an interview with a manager from the City of Columbus, Division of Water, Quality Assurance Lab, it was learned that the reservoirs, O'Shaughnessy and Griggs, located north of the DRWP along the Scioto River, serve as drinking water storage containers. These containers are utilized as mixing containers to alleviate some of the uncertainty and risk for the stochastic flows of the chemicals that flow from the land, into the water and are transported into the City of Columbus's drinking water. From Tables 7, 8a and 8b, it can be seen that this strategy works well for ammonia and phosphates, allowing them to mix and dissipate before they reach the raw water intake for the City of Columbus, Dublin Road Water Treatment Plant (DRWP). However, observations on the nitrogen flows, show the reservoirs to have little effect on alleviating the nitrogen run-off pollution. Instead of mixing and diluting the nitrate, this Nr is allowed to move through the system as if few or no safeguards were present.

From data retrieved from the Dublin Road Water Treatment Plant's Quality Assurance Lab, it is evident that there have been instances when the nitrogen levels in the finished drinking water were higher than the EPA's standard. The standard, based on the Safe Drinking Water Act (SDWA), enacted by Congress in the late 1970s, established a maximum concentration level (MCL) for substances in drinking water. The current nitrogen standard remains at 10 milligrams per liter or 10 parts per million and is also considered a safe minimum standard. A copy of the EPA's, Violation Report can be seen in Table 9a and a graph of the Dublin Road Water Plant's finished water monthly maximum Nitrate (as N) concentration (mg/l) from 1988 to 2003 is shown in Table 9b.

If people are willing to pay prices 240 to 10,000 times more for packaged water to protect themselves from the chance that their water may have higher then allowed nitrogen (contamination) levels, then this willingness implies they would be willing to pay an equivalent amount for an improvement in water quality. Such an improvement in water quality could be made with an investment in a cost effective nitrogen pollution abatement strategy, namely wetlands.

Investments in wetlands would not only reduce the risk of nitrogen pollution, for which no protection is now taken, but they would treat all of the other contaminants that end up in the water. This would reduce the amount of chemicals needed to treat drinking water for other contaminants, thus lowering average treatment costs by municipalities. Such actions could also lower the risk level to drinking water consumers and decrease the uncertainty that exists concerning tap water. Of course, the end results are that wetlands could lead to a reduction in averting behavior by individuals and municipalities. Wetlands are more that just natural spaces, they have value as pollution abatement strategies, storm and climate stabilization, their ability to provide biodiversity. More quantifiable values of wetlands are likely to emerge in the future as there are many research experiments being conducted on the amount of nitrogen a wetland can effectively absorb.

Opportunities for Future Research

Future research must include the upkeep of bottled water data. As a minimum, efforts should be made to collect data from at least one retail chain for 2004 and future years so that averting expenditure analyses can be conducted in case of another nitrogen advisory. As one can see from Appendix B, the City of Columbus, Division of Water, has no scheduled treatment for nitrogen pollution in the absence of an advisory indicating increased nitrogen is threatening the drinking water supply. If a nitrogen advisory were to occur, data on packaged water sales would be extremely valuable. Analyses of the data would allow one to see changes in purchases by consumers from an increase in actual and perceived risk from pollution and this would be useful for decision making.

There is also the possibility of future contingent valuation method (CVM) studies. A recent PhD Dissertation from the University of Nebraska-Lincoln (Sukharomana, 1998) conducted a willingness to pay study comparing differences in willingness to pay between contingent valuation and averting expenditures within one survey instrument. A questionnaire was developed that had both willingness to pay questions involving bid amounts and averting expenditure questions involving past averting behavior by residents that had experienced a contamination event. This study found that the true willingness to pay lies somewhere between the lower bound averting expenditure survey results and the upper bound contingent valuation bid amounts. The main policy implication that came out of this CVM study was very similar to this research project's findings: that there is considerable potential financial support for drinking water quality improvement programs.

The last aspect for future studies evolves from the research involving the uncertainty and risk that encapsulate nonpoint source pollution and wetlands as its control strategy. Bystom, Andersson and Gren (2000) introduce the concept of Nitrogen Abatement Uncertainty into the Pollution Control constraint, PC*. The authors address an overall uncertainty of pollution abatement capacity and the impacts of point source and nonpoint source (NPS) pollution and their stochastic nature. Their model presents probability as it enters the cost equation, where a parameter that specifies the weight of emissions is attached to the variance of emissions in order for the abatement target [the pollution constraint amount; PC*] to be reached with a probability of α. This could lead nitrogen control strategies to be analyzed through Minimum Variance Portfolio Theory where nitrogen pollution control instruments can be evaluated as portfolios of minimum risk on the portfolio possibility set, assuming EV (expected value) preferences.

Future Policy Implications

This research has provided an averting expenditure estimate that can be used in the benefit-cost analysis to determine the benefit of increased investments in the use of cost efficient nitrogen and pollution abatement strategies or wetlands.

Although a relatively small portion of the total benefits of cleaner water, averting costs analysis seems to have the potential to become a much larger component of the benefits assessment for hazardous waste and pollution control efforts. This method has a sound theoretical basis and the results are of sufficient magnitude that they merit consideration in future research and in surface and groundwater policy decisions in Columbus, Ohio and elsewhere.

This study sheds many insights on the expenditures consumers make on drinking water to maintain constant utility. This lower bound estimate ultimately results in an economic value placed on the importance of increasing the use of nitrogen nonpoint source (NNPS) pollution abatement technologies, especially wetlands, for their cost-effective ability to absorb NNPS pollution.

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Tables and Figures

Total Ounces					
Store Number	Mean	Median	Maximum	Minimum	Std. Dev.
1	54908.00	55588.00	81664.00	29160.00	8987.86
2	41886.15	43256.00	61200.00	26344.00	8073.82
3	108738.30	107344.00	138240.00	88584.00	11927.23
4	69948.77	69888.00	96440.00	45352.00	13433.73
5	33751.69	33624.00	52080.00	21088.00	5852.85
6	58790.62	58472.00	72808.00	44216.00	8153.53
7	86497.08	86856.00	114720.00	62448.00	11869.86
8	58846.77	59964.00	82440.00	37624.00	10956.17
9	57998.15	60316.00	86040.00	37896.00	10492.96
10	65986.46	66596.00	90264.00	37856.00	10424.65
11	70981.38	70972.00	97056.00	52592.00	8542.13
12	49441.38	48612.00	78728.00	34464.00	8151.96
13	97232.31	97344.00	176520.00	67064.00	19038.25
14	103429.50	100876.00	150536.00	73248.00	19186.88
15	105435.70	105272.00	136528.00	65616.00	16735.69
16	52624.00	52348.00	79688.00	33488.00	8969.50
17	101570.80	102216.00	142024.00	81416.00	12770.87
18	73388.92	72704.00	102848.00	54528.00	11275.98
Total Sales					
Store Number	Mean	Median	Maximum	Minimum	Std. Dev.
1	417.29	412.00	616.00	221.00	71.66
2	317.92	327.00	469.00	202.00	62.69
3	821.46	830.00	1112.00	638.00	95.39
4	536.92	534.00	794.00	360.00	107.61
5	262.40	263.50	412.00	161.00	46.25
6	458.81	454.50	587.00	354.00	61.13
7	646.50	632.50	903.00	468.00	93.01
8	449.81	458.50	632.00	302.00	78.90
9	439.37	441.00	700.00	292.00	82.80
10	493.52	499.50	678.00	310.00	75.10
11	556.67	552.00	750.00	413.00	64.86
12	383.29	376.50	552.00	263.00	60.82
13	738.46	730.00	1289.00	519.00	136.25
14	767.13	748.00	1175.00	563.00	145.32
15	830.10	837.50	1103.00	522.00	128.14
16	405.08	397.50	643.00	256.00	69.71
17	784.38	782.00	1165.00	619.00	102.76
18	544.25	536.50	815.00	396.00	89.15
Total Weighted Price					
Store Number	Mean	Median	Maximum	Minimum	Std. Dev.
1	1.66	1.69	1.86	1.38	0.12
2	1.59	1.59	1.91	1.15	0.14
3	1.69	1.71	1.96	1.39	0.14
4	1.69	1.69	1.97	1.42	0.13
5	1.73	1.74	2.01	1.45	0.12
6	1.84	1.88	2.08	1.48	0.15
7	1.63	1.66	1.87	1.38	0.12
8	1.74	1.78	2.00	1.33	0.16
9	1.66	1.70	1.85	1.25	0.13
10	1.64	1.64	2.18	1.39	0.14
11	1.94	2.00	2.18	1.63	0.15
12	1.78	1.81	2.00	1.49	0.15
13	1.68	1.70	1.86	1.37	0.14
14	1.60	1.63	1.88	0.91	0.16
15	1.89	1.94	2.11	1.47	0.16
16	1.79	1.80	1.99	1.50	0.13
17	1.75	1.80	1.99	1.32	0.15
18	1.61	1.60	1.85	1.44	0.10

Table 1a.: Bulk Water Data, Summary Statistics

Total Ounces					
Store Number	Mean	Median	Maximum	Minimum	Std. Dev.
1	41200.71	39254.74	77512.41	20976.29	12080.08
2	37169.39	30663.28	130353.70	15118.98	22466.02
3	61431.33	52013.88	190585.80	29754.08	33440.60
4	66520.00	53638.56	258212.60	29823.49	37417.23
5	27894.90	26733.22	75131.46	11246.97	12121.55
6	88808.67	80223.51	220558.60	42529.24	39279.93
7	94320.80	78649.60	270025.00	45972.34	49986.64
8	57717.84	51057.72	154808.80	33512.39	25880.41
9	67900.46	54876.34	233186.10	22399.35	44001.69
10	59596.59	47938.77	254500.50	25040.99	42923.24
11	109945.90	86964.61	256446.30	55599.50	49877.41
12	104533.20	84110.78	263204.90	51916.37	52834.29
13	87627.49	76087.92	187208.20	47446.94	31872.25
14	51751.29	40749.11	177779.00	20837.83	33818.61
15	150044.20	143992.60	351821.90	89448.82	49263.73
16	59554.76	56779.10	131830.00	27325.86	20710.36
17	70249.00	63125.42	168158.50	39697.01	27681.28
18	73613.10	58369.11	303356.60	30069.15	50467.99
Total Sales					
Store Number	Mean	Median	Maximum	Minimum	Std. Dev.
1	894.38	880.50	1517.00	476.00	196.23
2	715.81	629.00	2199.00	334.00	328.68
3	1207.33	1114.00	2757.00	702.00	433.50
4	1357.06	1194.00	3614.00	776.00	473.22
5	633.13	609.50	1409.00	280.00	202.29
6	1764.79	1710.50	3253.00	976.00	503.83
7	1749.52	1654.50	3840.00	1136.00	556.27
8	1159.42	1120.50	2266.00	742.00	319.90
9	1205.44	1122.50	3258.00	564.00	525.56
10	1068.60	912.00	3237.00	589.00	482.03
11	2036.00	1816.50	3379.00	1272.00	542.28
12	2000.60	1857.50	3899.00	1260.00	618.62
13	1712.56	1661.50	2771.00	1074.00	338.33
14	981.27	887.00	2556.00	513.00	401.02
15	3136.54	3027.00	5994.00	2044.00	698.61
16	1280.67	1250.50	2536.00	635.00	327.26
17	1460.27	1378.50	2754.00	1009.00	372.37
18	1271.79	1150.50	3950.00	691.00	581.49
Total Weighted Price					
Store Number	Mean	Median	Maximum	Minimum	Std. Dev.
1	3.56	3.50	4.48	2.55	0.42
2	3.10	3.05	4.15	2.35	0.45
3	3.29	3.23	4.56	2.28	0.53
4	3.50	3.33	4.65	2.36	0.55
5	3.12	3.07	4.33	2.21	0.48
6	3.20	3.13	4.24	2.29	0.46
7	3.12	3.09	3.91	2.26	0.40
8	3.41	3.39	4.21	2.57	0.39
9	3.30	3.21	4.27	2.29	0.50
10	3.19	3.10	4.37	2.30	0.46
11	3.55	3.61	4.46	2.58	0.45
12	3.49	3.50	4.68	2.50	0.51
13	3.55	3.53	4.59	2.55	0.48
14	3.25	3.25	4.61	2.37	0.49
15	3.71	3.70	4.47	2.95	0.33
16	3.43	3.41	4.30	2.49	0.38
17	3.37	3.37	4.05	2.54	0.35
18	3.07	3.04	4.31	2.12	0.49

Table 1b.: Bottled Water Data, Summary Statistics

Variable	Description of Variable
These variables do not vary for every store and are evaluated as common pooled coefficients.	
AVEWKLYMAXTEMP	This variable is the weekly average maximum temperature taken from the Record of Climatological Observations, taken at the Columbus, Ohio, Franklin County, Port Columbus International Airport for the year 2002. This is associated with the weekly packaged water sales data.
D1	0 / 1 Dummy Variable representing Winter or the months January, February, and March
D2[1]	0 / 1 Dummy Variable representing Summer or the months July, August, and September
D3	0 / 1 Dummy Variable representing Fall or the months October, November and December
NEWSEVENTSBAD	This variable is a tally of the 2002 Columbus Dispatch news articles that reported bad news concerning water quality, nitrogen, or any water advisory. The news events were tallied by week, corresponding to the weekly packaged water sales data.
WEEKLYPREC	This variable is the total amount of weekly precipitation received at the Olentangy River Wetland Research Park, weather station, located in the center of Columbus, Ohio along the Olentangy River.
INOUTAREA	Dummy variable used to differentiate between the stores within the Dublin Road Water Treatment Plant service area or outside of the Dublin Road Water Treatment Plant service area
PCTINCUNDER10	This variable consists of the percentage of people living in the market area of any given grocery store whose income are less than $10,000. This variable does change for every store however, the results will be reported as a common pool coefficient
DVJUNE	0 / 1 Dummy Variable used to describe the hypothesis of if there is a June effect, also referred to as the Cleanliness Variable
DVHOLIDAY	0 / 1 Dummy Variable used to describe the effect of major holidays near the month of June. The holidays include Memorial Day, Labor Day, the 4th of July, Thanksgiving, Christmas and New Years.
These variables vary for every store and are evaluated with cross section specific coefficients	
TOTALWEIGHTEDPRICE	This variable consists of the total weighted price per week. This variable is estimated by store as a cross section specific coefficients
TOTALOUNCESSOLD	This is the dependent variable. This variable consists of the total ounces of water sold per week. This variable is estimated by store as cross section specific coefficients

Table 2: Description of the variables used in the models.

[1] The Spring Dummy Variable representing the months April, May, June, will be the variable receiving the zero, since multicollinearity was experienced between itself and the research variable.

Dependent Variable: TOTALBOUNCESSOLD?
Method: Pooled Least Squares
Date: 12/29/04 Time: 18:49 **BOTTLED IN**
Sample: 1 52
Included observations: 52
Number of cross-sections used: 6
Total panel (balanced) observations: 312

Variable	Coefficient	Std. Error	t-Statistic	Prob.
WEIGHTUNITPRICE?	-21105.8	5004.343	-4.21749	0.0000
WEEKLYPRECIPITATION	1697.796	640.3281	2.651447	0.0084
AVEWEEKLYMAXTEMP	263.9371	235.1198	1.122564	0.2625
DV1WINTER	-12966.5	7662.093	-1.69229	0.0916
DV3SUMMER	4336.83	7676.158	0.564974	0.5725
DV4FALL	-6681.11	8087.006	-0.82615	0.4094
DVHOLIDAY	34619.69	5117.508	6.764951	0.0000
NEWSEVENTSBAD	4002.853	2851.034	1.404	0.1614
DVJUNE	19793.9	8408.575	2.354014	0.0192
Fixed Effects				
_221--C	89988.86			
_315--C	114080.1			
_412--C	67458.83			
_519--C	133723.7			
_598--C	111179.2			
_942--C	201926.2			

R-squared	0.716392	Mean dependent va	74646.85
Adjusted R-squared	0.703023	S.D. dependent var	54673.86
S.E. of regression	29794.85	Sum squared resid	2.64E+11
Log likelihood	-3649.28	F-statistic	53.58705
Durbin-Watson stat	1.695551	Prob(F-statistic)	0

Dependent Variable: TOTALOUNCES?
Method: Pooled Least Squares
Date: 12/27/04 Time: 13:12 **BULK IN**
Sample: 1 52
Included observations: 52
Number of cross-sections used: 6
Total panel (balanced) observations: 312

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TOTALWEIGHTPRICE?	-10472.5	4487.056	-2.33393	0.0203
AVEWEEKLYMAXTEMP	-44.3145	74.08278	-0.59818	0.5502
DV1WINTER	-3299.95	2219.416	-1.48685	0.1381
DV3SUMMER	-9757.18	2187.974	-4.45946	0.0000
DV4FALL	-17962.4	2113.941	-8.4971	0.0000
DVHOLIDAY3	3262.146	2427.714	1.343711	0.1801
NEWSEVENTSBAD	326.5509	863.1377	0.37833	0.7055
DVJUNE	2106.66	2637.596	0.798705	0.4251
Fixed Effects				
_212--C	82307.7			
_315--C	97605.81			
_412--C	61870.38			
_519--C	113529.2			
_598--C	85360.1			
_942--C	135195.6			

R-squared	0.878584	Mean dependent va	68089.9
Adjusted R-squared	0.873287	S.D. dependent var	25869.1
S.E. of regression	9208.548	Sum squared resid	2.53E+10
Log likelihood	-3283.45	F-statistic	1.66E+02
Durbin-Watson stat	1.325098	Prob(F-statistic)	0

Dependent Variable: TOTALBOUNCESSOLD?
Method: Pooled Least Squares
Date: 12/29/04 Time: 18:48 **BOTTLED OUT**
Sample: 1 52
Included observations: 52
Number of cross-sections used: 12
Total panel (balanced) observations: 624

Variable	Coefficient	Std. Error	t-Statistic	Prob.
WEIGHTUNITPRICE?	-16174.7	3394.464	-4.76503	0.0000
WEEKLYPRECIPITATION	887.7248	445.5762	1.992307	0.0468
AVEWEEKLYMAXTEMP	233.7612	165.8108	1.409807	0.1591
DV1WINTER	-19256.8	5329.438	-3.61329	0.0003
DV3SUMMER	1344.298	5382.094	0.249772	0.8028
DV4FALL	-15327.9	5411.459	-2.83249	0.0048
DVHOLIDAY	37573.36	3565.842	10.53702	0.0000
NEWSEVENTSBAD	4622.472	1979.422	2.335263	0.0199
DVJUNE	11196.01	5909.695	1.894515	0.0586
Fixed Effects				
_282--C	69509.35			
_299--C	96907.63			
_417--C	122738.9			
_595--C	95035.82			
_815--C	93497.76			
_818--C	149670.5			
_839--C	143272.6			
_853--C	127234.6			
_941--C	86551.58			
_971--C	97235.36			
_988--C	106975.9			
_990--C	105450.7			

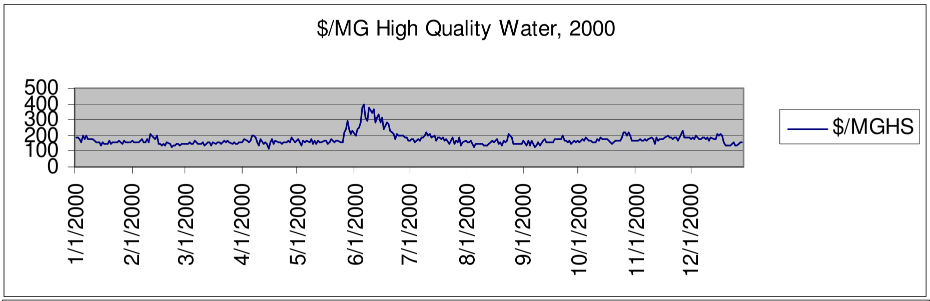
R-squared	0.543798	Mean dependent va	71833.21
Adjusted R-squared	0.528667	S.D. dependent var	42669.1
S.E. of regression	29293.92	Sum squared resid	5.17E+11
Log likelihood	-7292.66	F-statistic	35.93915
Durbin-Watson stat	1.559515	Prob(F-statistic)	0

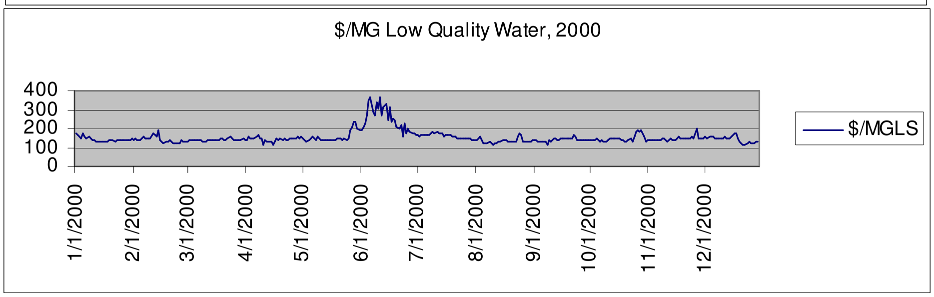
Dependent Variable: TOTALOUNCES?
Method: Pooled Least Squares
Date: 12/27/04 Time: 13:10 **BULK OUT**
Sample: 1 52
Included observations: 52
Number of cross-sections used: 12
Total panel (balanced) observations: 624

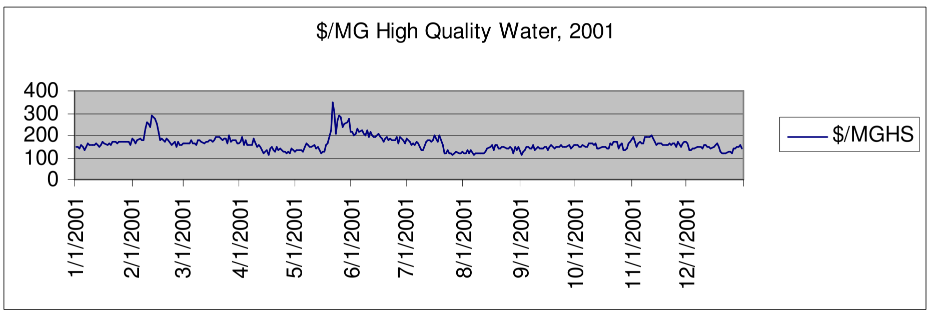
Variable	Coefficient	Std. Error	t-Statistic	Prob.
TOTALWEIGHTPRICE?	-16641.8	3062.133	-5.4347	0.0000
AVEWEEKLYMAXTEMP	-17.8766	56.11007	-0.3186	0.7501
DV1WINTER	-1021.32	1679.574	-0.60808	0.5434
DV3SUMMER	-9467.01	1663.397	-5.69137	0.0000
DV4FALL	-12373.6	1600.693	-7.73012	0.0000
DVHOLIDAY3	5199.865	1840.126	2.82582	0.0049
NEWSEVENTSBAD	2421.685	654.9253	3.69765	0.0002
DVJUNE	3099.245	1994.214	1.554119	0.1207
Fixed Effects				
_282--C	73111.59			
_299--C	141648			
_417--C	94177.61			
_595--C	92665.74			
_815--C	98070.89			
_818--C	108090.6			
_839--C	83947.93			
_853--C	129951.4			
_941--C	134862.9			
_971--C	87154.88			
_988--C	135518.7			
_990--C	104969.6			

R-squared	0.852838	Mean dependent va	73576.38
Adjusted R-squared	0.848208	S.D. dependent var	25362.01
S.E. of regression	9881.151	Sum squared resid	5.90E+10
Log likelihood	-6615.05	F-statistic	1.84E+02
Durbin-Watson stat	1.633908	Prob(F-statistic)	0

Table 3: The four regression models: Bottled and Bulk water INSIDE the advisory area and Bottled and Bulk water OUTSIDE of the advisory area.







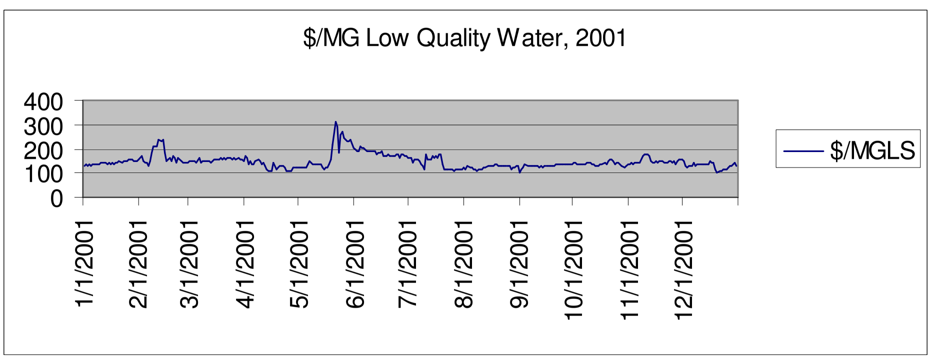
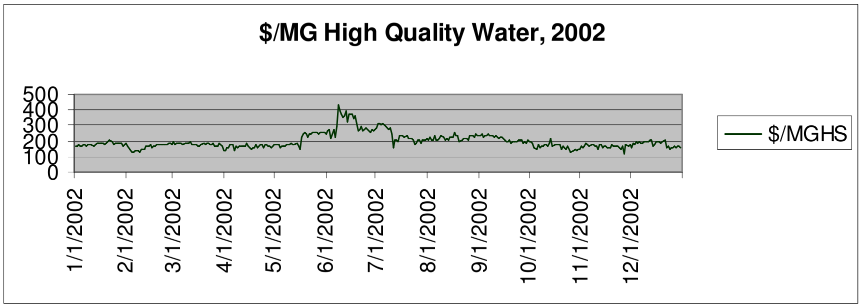
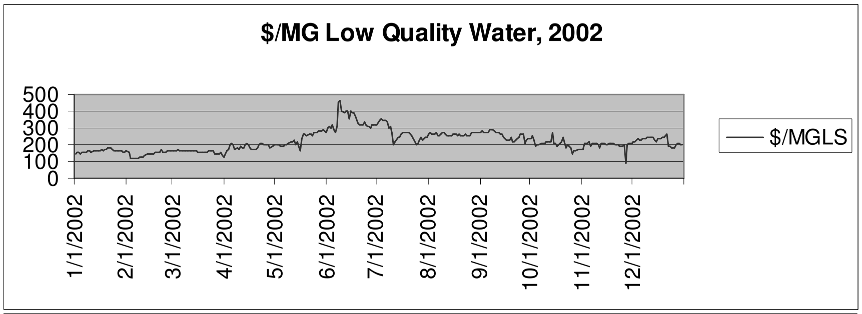
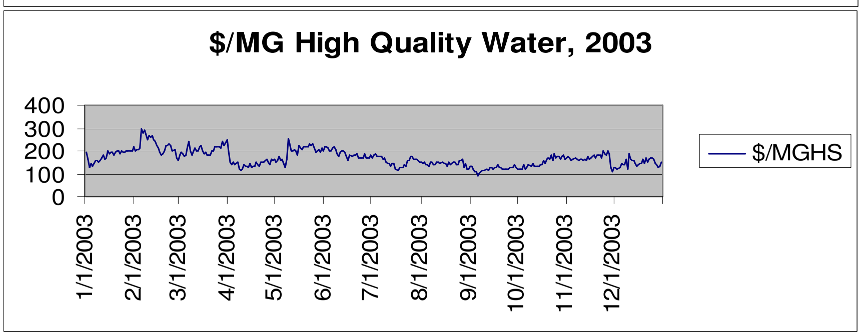


Table 4a.: Daily Average Water Treatment Costs of the Dublin Road Water Treatment Plant per million gallons, years 2000 and 2001.

Continued







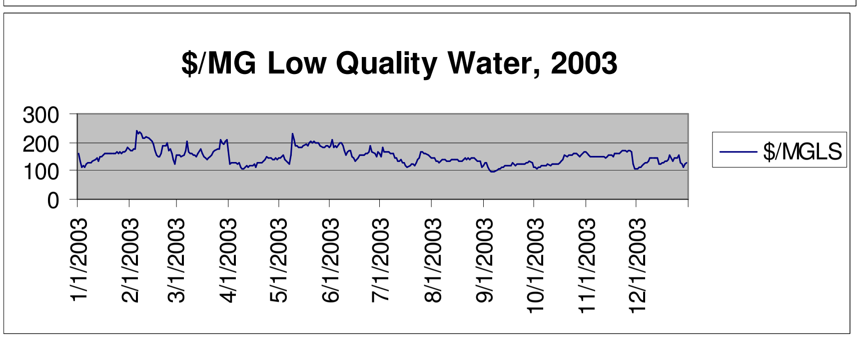


Table 4b: Daily Average Water Treatment Costs of the Dublin Road Water Treatment Plant per million gallons, years 2002 and 2003.

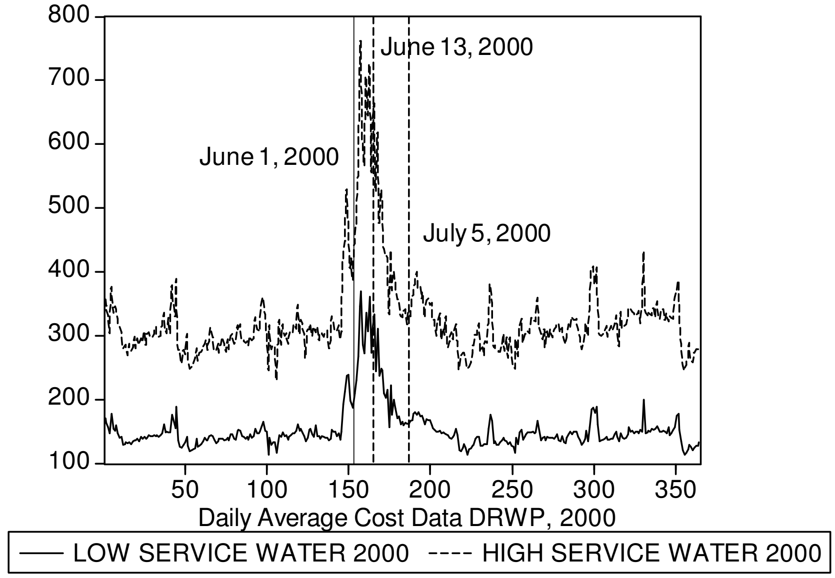


Table 5a.: Daily average treatment cost data for DRWP for 2000. Low service and high service water is depicted along with lines representing June 1; the research variable and June 13 through July 5, 2000; the nitrogen advisory.

City of Columbus Water Treatment Costs for the years 2000, 2001 and 2002 for the Dublin Road Water Treatment Plant									
Dependent Variable: HIGHQUALITY?					Dependent Variable: LOWQUALITY?				
Method: Pooled Least Squares					Method: Pooled Least Squares				
Date: 11/22/04 Time: 13:51					Date: 11/22/04 Time: 13:53				
Sample: 1 365					Sample: 1 365				
Included observations: 365					Included observations: 365				
Number of cross-sections used: 3					Number of cross-sections used: 3				
Total panel (balanced) observations: 1095					Total panel (balanced) observations: 1095				
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Variable	Coefficient	Std. Error	t-Statistic	Prob.
_2000--DVJUNE	**97.7299**	6.099485	16.02265	0.0000	_2000--DVJUNE	**103.0085**	6.673647	15.43511	0.0000
_2001--DVJUNE	**36.23784**	6.099485	5.941131	0.0000	_2001--DVJUNE	**39.24168**	6.673647	5.880095	0.0000
_2002--DVJUNE	**118.2208**	6.099485	19.38209	0.0000	_2002--DVJUNE	**135.8436**	6.673647	20.35523	0.0000
Fixed Effects					Fixed Effects				
_2000--C	165.6323				_2000--C	145.0298			
_2001--C	158.7838				_2001--C	143.4221			
_2002--C	188.6393				_2002--C	209.4574			
R-squared	0.45685	Mean dependent var		177.93	R-squared	0.606971	Mean dependent v		173.59
Adjusted R-squared	0.454356	S.D. dependent var		43.329	Adjusted R-squared	0.605167	S.D. dependent va		55.731
S.E. of regression	32.00588	Sum squared resid		1E+06	S.E. of regression	35.01868	Sum squared resid		1E+06
Log likelihood	-5345.911	F-statistic		183.19	Log likelihood	-5444.42	F-statistic		336.36
Durbin-Watson stat	0.402955	Prob(F-statistic)		0	Durbin-Watson stat	0.261227	Prob(F-statistic)		0

Table 5b.: Regressions performed on the average treatment costs from DRWP, where treatment costs are the dependent variable and the dummy variable DVJUNE was applied as the independent variable. Cross sections by year and fixed effects were applied.

Model		Weighted Unit Price?	Weekly Precipitation	Average Weekly Max. Temp	DV1 Winter	DV3 Summer	DV4Fall	DV Holidays	News Events Bad	DV June
Bulk Water In Area	Coefficient	-10472.49		-44.31452	-3299.946	-9757.183	-17962.36	3262.146	326.5509	2106.66
Adj. r2 = .878	t-stat	-2.333934		-0.598176	-1.486853	-4.459461	-8.497096	1.343711	0.37833	0.798705
F Stat = 166.87	p-value	0.0203		0.5502	0.1381	0.0000	0.0000	0.1801	0.7055	0.4251
Bottled Water In Area	Coefficient	-21105.75	1697.796	263.9371	-12966.51	4336.83	-6681.113	34619.69	4002.853	19793.9
Adj. r2 = .703	t-stat	-4.217487	2.651447	1.122564	-1.692294	0.564974	-0.826154	6.764951	1.404	2.354014
F Stat = 53.58	p-value	0.0000	0.0084	0.2625	0.0916	0.5725	0.4094	0.0000	0.1614	0.0192
Bulk Water Out Area	Coefficient	-16641.76		-17.87662	-1021.323	-9467.014	-12373.55	5199.865	2421.685	3099.245
Adj. r2 = .848	t-stat	-5.434696		-0.318599	-0.608084	-5.691374	-7.730119	2.82582	3.69765	1.554119
F Stat = 184.23	p-value	0.0000		0.7501	0.5434	0.0000	0.0000	0.0049	0.0002	0.1207
Bottled Water Out Area	Coefficient	-16174.72	887.7248	233.7612	-19256.78	1344.298	-15327.91	37573.36	4622.472	11196.01
Adj. r2 = .528	t-stat	-4.765029	1.992307	1.409807	-3.613286	0.249772	-2.832492	10.53702	2.335263	1.894515
F Stat = 35.93	p-value	0.0000	0.0468	0.1591	0.0003	0.8028	0.0048	0.0000	0.0199	0.0586

Table 6a.: The regression results for the independent variables from the four models; bulk in, bottled in, bulk out, bottled out.

City of Columbus, Division of Water								
	Division of Water, Low Quality Treatment Costs			Division of Water, High Quality Treatment Costs			Low	High
	2000	**2001**	**2002**	**2000**	**2001**	**2002**	**2000**	**2000**
Total Gallons Treated, (Billion)	51	52	54	51	52	54	Averting Expenditres relating to Nitrogen Advisory Only	
Total gallons treated of High Quality water at the Dublin Road Water Plant	19,105,780,000	19,183,650,000	20,083,730,000	19,105,780,000	19,183,650,000	20,083,730,000	19,105,780,000	19,105,780,000
Gallons Treated Per Day	52,344,603	52,557,945	55,023,918	52,344,603	52,557,945	55,023,918	52,344,603	52,344,603
$/1 mill gal per day over the average cost	**102.8883417**	**39.096871**	**136.1766955**	**97.52739701**	**35.99246203**	**118.4831847**	**72.20767**	**62.93692**
Ratio	**0.000102888**	**3.90969E-05**	**0.000136177**	**9.75274E-05**	**3.59925E-05**	**0.000118483**	**7.22077E-05**	**6.29369E-05**
Cost per day	**$5,385.65**	**$2,054.85**	**$7,492.98**	**$5,105.03**	**$1,891.69**	**$6,519.41**	**$3,779.68**	**$3,294.41**
Averting Expenditure by City of Columbus per year for High and Low Quality water for the research varaible (30 days of June)	$161,569.48	$61,645.54	$224,789.26	$153,150.99	$56,750.70	$195,582.27	$86,932.68	$75,771.39
SUM				$161,569.48	$61,645.54	$224,789.26		$86,932.68
Total averting expenditures by year for the month of June				$314,720.47	$118,396.23	$420,371.53		$162,704.07

Table 6b.: Averting expenditure worksheet for Daily Average water treatment cost data from the City of Columbus Division of Water, Dublin Road Water Treatment Plant for the years 2000, 2001, and 2002, for the month of June. The Last two columns are Averting Expenditures for the 2000 nitrogen advisory only.

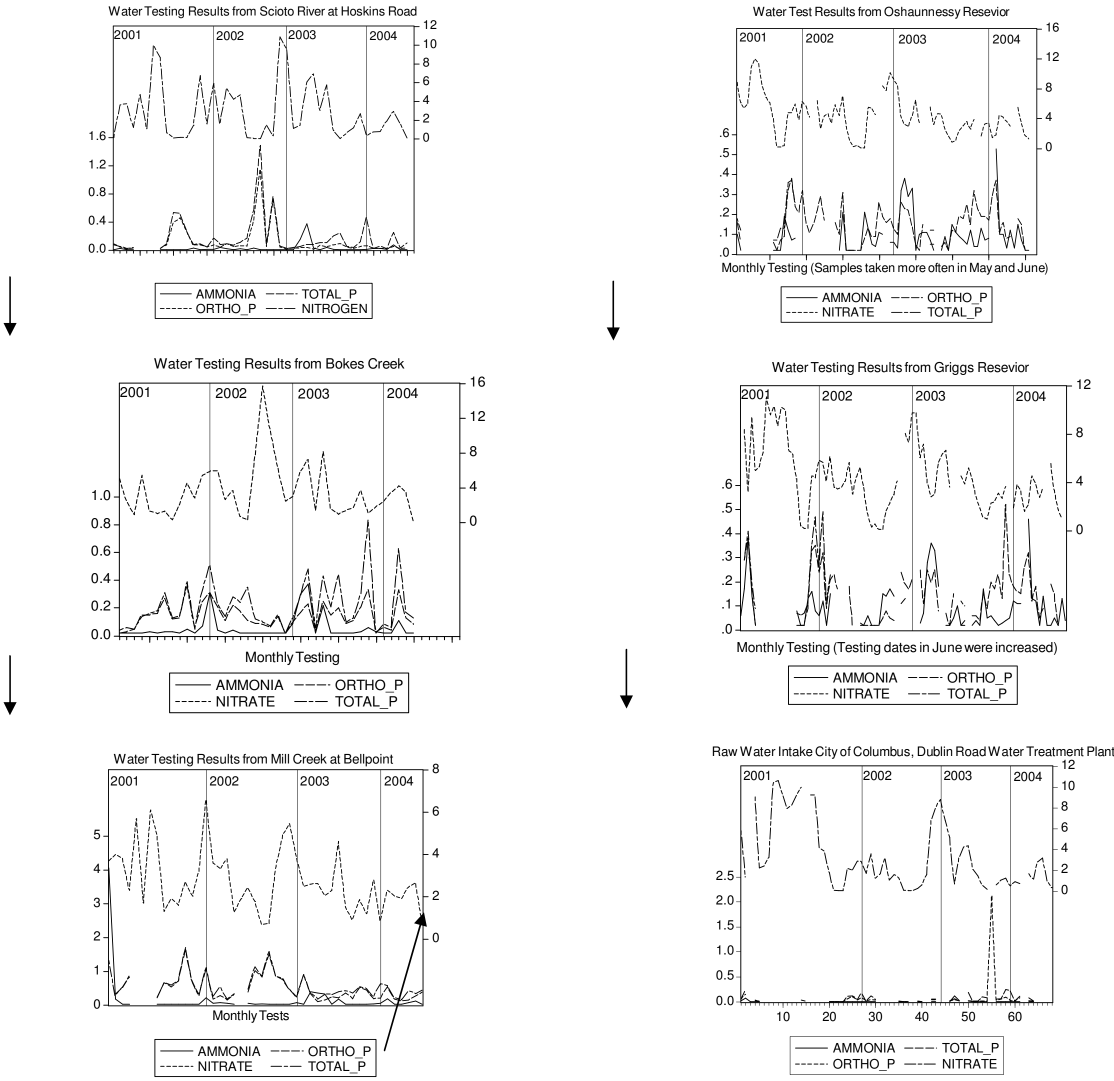


Table 7: Flows of Ammonia, Ortho Phosphorus, Total Phosphorus and Nitrate, as nitrogen, are depicted as they flow down the Scioto River, from Jan. 2001 to June 2004. Source: City of Columbus, Division of Water Quality Assurance Lab, USGS flow samples from 6 of their testing stations along the Scioto River. Monthly data - some months (May & June) had more than one reading. Flows represent stochastic nature of nonpoint source pollution or uncertainty.

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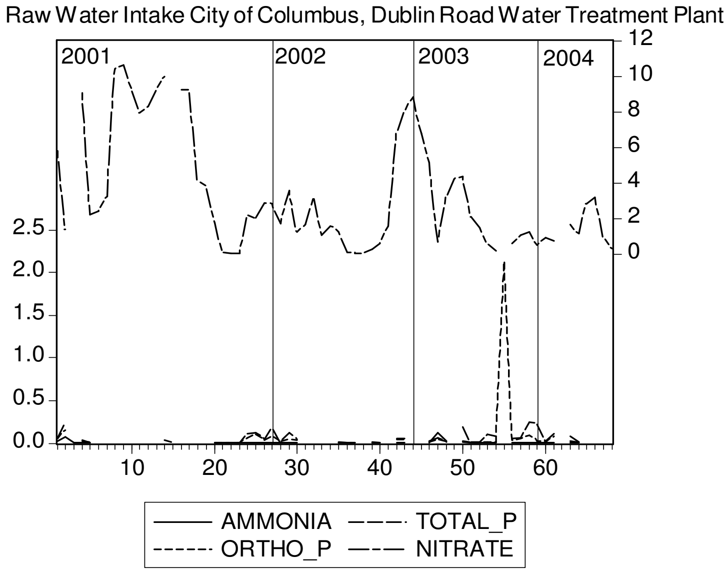

Table 8a.: Source: City of Columbus, Division of Water Quality Assurance Lab's data from the USGS.

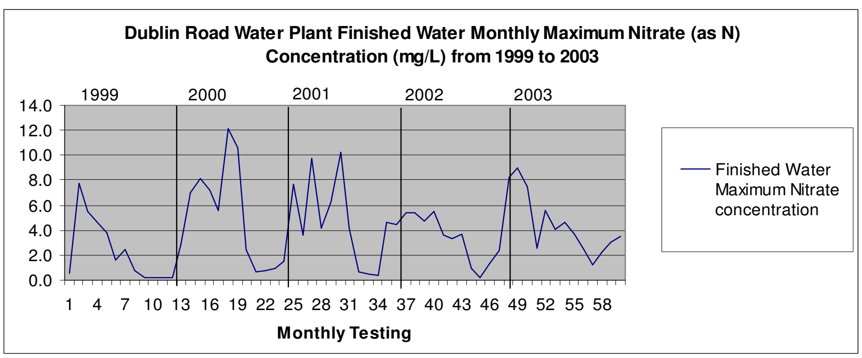

Table 8b.: Dublin Road Water Plant finished water monthly maximums nitrate (as N) concentration from 1999 to 2003

Violation Report
COLUMBUS PUBLIC WATER SYSTEM

COLUMBUS, OH 43215 614-645-7020
Primary Water Source Surface water Type Population Served 955,606
This report was created on OCT-14-2004
Results are based on data extracted on JUL-17-2004

NOTICE: EPA is aware of inaccuracies and underreporting of some data in the Safe Drinking Water Information System. We are working with the states to improve the quality of the data.
Health Based Violations: **amount of contaminant exceeded safety standard (MCL) or water was not treated properly.**

Type of Violation Contaminant Level Found Violation CodeMCL, Average	
Occurred Between: Begin Date	**JUN-01-2000**
Occurred Between: End Date	**NOV-30-2000**
Contaminant	Nitrate
Maximum Contaminant Level	**10**
Contaminant Level Found Violation CodeMCL, Average	**11.31081695**

Follow-up Action	Date of Response
St Violation/Reminder Notice	**AUG-02-2000**
St Public Notif requested	**AUG-02-2000**
St Compliance achieved	**JUL-05-2000**
St Public Notif received	**JUN-13-2000**

Table 9a. : A copy of the EPA's Violation Report for the nitrogen advisory occurring between June 13, 2000 and July 5, 2000.

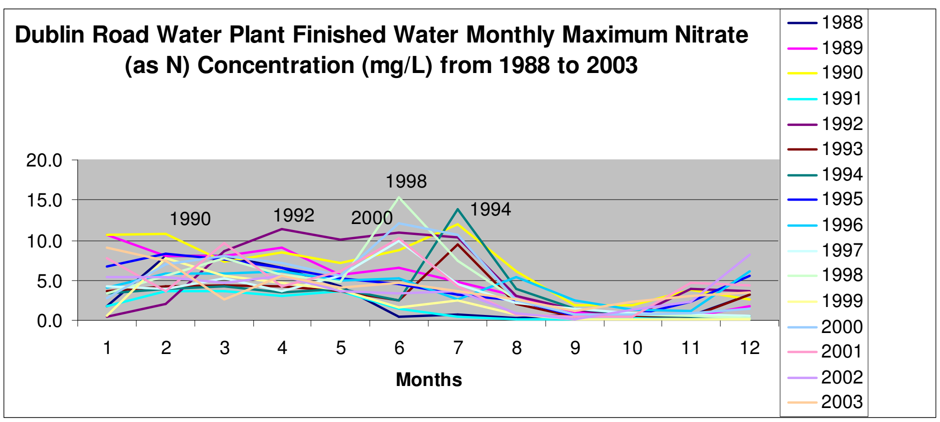

Table 9b.: Source, City of Columbus, Division of Water, Water Quality Assurance Lab. Finished water monthly maximums of nitrate concentrations from 1988 to 2003.