ILLINOIS POLLUTION CONTROL BOARD
September 29, 1975

IN THE MATTER OF PLANT NUTRIENTS	)	R71-15

OPINION AND ORDER OF THE BOARD (by Mr. Dumelle):

Certain nutrients are essential for the growth of all plants, including those that are used indirectly through animals or directly to produce most of man's food supply. These plant nutrients are obtained from various sources, including reserves in soils, plant and animal manures, fertilizers, etc. If there are excess supplies of plant nutrients, especially of nitrogen and to a lesser extent phosphorus, they may adversely affect water quality.

BOARD ACTION AND HEARINGS IN 1971 AND 1972

In May, 1971, the Illinois Pollution Control Board (Board) approved proposals for public hearings on the application of fertilizers, animal wastes, and sewage sludge and on controlled access of livestock to streams. The purposes of the hearings were to determine [In The Matter of Plant Nutrients,, R71-15, 4 PCB 127 (March 28, 1972)]:

"1. Whether plant nutrients are creating pollution problems by reaching surface or underground waters in excessive amounts.

2. The present state of knowledge on the extent to which fertilizers and animal manure contribute to pollution problems.

3. Whether steps can be taken to correct pollution problems in the event that problems are identified and agricultural practices are found to be important contributors. Two approaches were to be considered: (a) adoption of rules and regulations, and (b) reliance upon needed research, education, and voluntary changes in practices.

The Board expresses its appreciation to Dr. Russell T. Odell, a former Board Member, and Professor of Agronomy, Emeritus, University of Illinois, who prepared this Opinion in draft and discussed it at length with the Board.

4. The impact of alternative courses of action both on the environment and on food supply and costs.

5. The administrative feasibility of rules and regulations."

Information presented at ten public hearings indicated the status and trends of nitrates and phosphates in streams, the role of different crop production practices in determining the plant nutrient content of surface waters, and the environmental and economic consequences of alternative practices. However, the hearings also revealed major deficiencies in available information upon which the Board could make a decision concerning plant nutrients.

The Board Opinion of March 28, 1972 (In The Matter of Plant Nutrients, R71-15, 4 PCB 128-130), and especially Dr. S.R. Aldrich's Supplemental Statement of the same date, discuss in detail many aspects of nitrogen in relation to water quality. The nitrate content of surface waters is increasing in some streams and during short periods may exceed the Water Quality Standard of 10 mg/l nitrate nitrogen (45 mg/l nitrate) in certain streams in east-central Illinois. "Sources of excess nitrates in streams are well known but the magnitude of the contribution of each is unknown. Increases in fertilizer nitrogen and in the acreage of row crops are the most likely contributors. ...

"The record clearly supports the conclusion that within a given set of supporting cultural practices, the greater the amount of nitrogen applied the greater the potential for loss to ground and surface waters (Nov. 3, p. 52). But farmers who produce the highest yields and apply the highest rates of nitrogen may produce a unit of crop with less potentially leachable nitrate than farmers who produce average yields. Surveys reveal that recent increases in nitrogen consumption in Illinois, and for the entire Cornbelt, are due to higher rates being applied on previously underfertilized fields. The proportion of fields that receive more than 150 pounds per acre has decreased in recent years" (Plant Nutrients, 4 PCB 128). The increase in the cost of nitrogen from approximately 5 cents per pound in 1971 to 17 cents in 1975 has been greater than the change in the corn price per bushel, which increased from approximately $1.25 to $2.75 during the same period. This large and disproportionate increase in cost of nitrogen during recent years has caused farmers to monitor their nitrogen applications more carefully than when fertilizer was cheaper.

The Board concluded that "the water quality standards for nitrate nitrogen are presently being violated in certain streams of the state and that the potential nitrate problem will grow as the demand for food increases. The record has not demonstrated that health effects have resulted. Deficiencies in available knowledge on the credibility of the nitrate standard, on the contributions of various nitrogen sources to nitrates in water, on the effectiveness of possible control measures and on undesirable side effects on the environment from alternative practices convince us that at this time we should make provision for more information on which to decide the issue rather than to promulgate regulations of unpredictable effectiveness and side effects. Accordingly we shall ask the Institute for Environmental Quality to give high priority to obtaining information on nitrates which will provide a basis for early reconsideration of the matter."

"Specifically we request the Institute to develop an implementation plan for achieving the standard of 10 mg/l nitrate nitrogen in public drinking and food processing water or, if Institute studies show that the costs to achieve compliance are not justified by the benefits, to propose a revision. Perhaps additional research will be required in stream sampling, in connection with applications of fertilizer, animal and human wastes, in groundwater hydrology, and in cropping systems before an implementation plan can be developed. We suggest that the Institute also consider the technical feasibility and economic reasonableness of removing nitrates from public drinking and food processing water in case a choice becomes necessary at a future date between nitrate removal versus major adjustments in food production practices in order to reduce the sources of nitrates" (Plant Nutrients, 4 PCB 130).

Concern for phosphorus is caused by its possible role as a contributor to accelerated eutrophication of surface waters. "Phosphorus has been shown to be a serious water contaminant in the Fox River as well as in Lake Michigan (for which a phosphorus standard was established) and other still waters, but not in flowing streams generally. Nor has the evidence stressed the contribution of fertilizer runoff in these Illinois waters subject to serious phosphorus problems. ... The behavior of phosphorus fertilizer when applied to the soil is well known. Illinois soils have retention capacities for phosphorus far in excess of the amounts applied in fertilizer. Hence, phosphorus in tile drainage effluent is little affected by fertilizer applications" (Plant Nutrients, 4 PCB 131). Phosphorus is held closely by soil particles and is not mobile nor lost except by soil erosion. On the basis of testimony given, the Board decided that regulations on phosphorus fertilizer should not be imposed.

The Board found no support for a regulation to fence livestock from streams. It also decided not to adopt a regulation concerning rate of application of sludge on land since no nitrogen limit was established for fertilizer. Several aspects of these problems and of animal manures have been considered recently in Livestock Waste Regulations, R72-9, 13 PCB 451-469 (August 29 and September 5, 1974).

I.I.E.Q. DOCUMENT NO. 74-38, FERTILIZER APPLICATION RATES AND NITRATE CONCENTRATIONS IN ILLINOIS SURFACE WATERS (December 1974)

In response to the request of the Board on March 28, 1972 (Plant Nutrients, R71-15, 4 PCB 130), the Illinois Institute for Environmental Quality (Institute) contracted with the Center for the Biology of Natural Systems (CBNS), Washington University, to (1) analyze "the relationship between observed concentrations of nitrate in Illinois rivers and the rate of application of nitrogen fertilizer to Illinois farmlands, and (2) from this analysis to determine what influence various limitations of the rate of nitrogen application might be expected to have on nitrate levels" (Institute Doc. 74-38, page 1).

Variations in nitrate concentrations among Illinois rivers are due to (1) variations among different sampling points, (2) variations during different seasons of the year at a specified sampling station, and (3) variations from year to year during specified seasons at a specific sampling station. Nitrate nitrogen values range "from less than 1 ppm in certain rivers in southern Illinois to over 10 ppm in east-central Illinois rivers" (Institute Doc. 74-38, page 5). Average nitrate plus nitrite nitrogen and total phosphorus values for 1974 in the sub-basins in Illinois are given in Table 1; seasonal values will range more widely. Land use varies markedly among different watersheds which drain to various sampling stations. This is the major relationship studied by CBNS. Nitrate concentrations in streams are usually highest during the spring months each year. Mean nitrate nitrogen concentration for samples in the spring (April through June) is the measure of water quality used in this analysis.

Table 1. Average values of nitrate plus nitrite nitrogen and total phosphorus for 1974 within sub-basins In Illinois.*

Sub-basin	Major basin	Nitrates plus nitrites as N	Total phosphorus
		mg/l	mg/l
Shore water	Lake Michigan	0.3	0.06
Lake Michigan trib.	" "	0.1	0.16

Sub-basin	Major basin	Nitrates plus nitrites as N	Total phosphor
		mg/l	mg/l
Des Plaines direct	Des Plaines	2.1	0.80
Du Page River	" "	3.5	2.00
Chicago San. & Ship Can.	" "	1.7	1.78
Fox River	Illinois	2.4	0.31
Kankakee River	Illinois	4.7	0.22
Sangamon River	"	5.5	0.44
Illinois direct	"	4.8	0.54
Rock River	Mississippi	3.8	0.45
Mississippi R. North	"	3.2	0.43
Mississippi R. Central	"	1.3	0.38
Kaskaskia River	Mississippi	2.0	0.41
Bid Muddy River	"	0.8	0.46
Mississippi R. South	"	1.1	0.38
Wabash River	Ohio	3.4	0.41
Saline River	"	1.2	0.20
Ohio direct	"	1.2	0.17

*Illinois Water Quality Inventory Report 1975.
Illinois Environmental Protection Agency.

The Illinois Environmental Protection Agency has identified eight Illinois towns with seasonally elevated nitrate levels in surface water supplies. All of these towns are in East-Central Illinois (see page 9). The eight towns are Decatur, in the Sangamon River sub-basin (Table 1); Bloomington, Eureka, Pontiac, and Streator in the Illinois direct sub-basin; and Charleston, Danville, and Georgetown in the Wabash River sub-basin.

The general approach in this study was to determine the mathematical relationship between nitrate nitrogen concentrations in streams and factors, especially nitrogen fertilizer, which are expected to influence nitrate concentrations. Calculations were then made to estimate changes needed in agricultural practices to reduce nitrate concentrations to acceptable levels. Finally, estimates were made of the impact of such changes in agricultural practices on crop production and income.

Relationships Between Nitrate Nitrogen in Surface Waters and Selected Variables

In regression analysis, the choice of "independent" variables that are expected to influence the dependent variable (nitrate concentration in streams) is very important. Sources of nitrates in streams include effluent from sewage treatment plants and diffuse sources, such as drainage from land. Under natural conditions, nitrate is produced in the soil by bacterial action on organic matter. The rate at which nitrate is released from soil organic matter is affected by temperature, moisture, soil type, and agricultural practices such as percent of land in row crops, which stimulates nitrate release. CBNS used the percent of land in row crops (corn and soybeans) as a proxy measure of nitrate from soil organic matter. A more direct measure of nitrogen released from soil organic matter would have been the estimated amount of soil organic matter per watershed acre, which can be estimated from data in the University of Illinois Agronomy Department. Row crops are grown most extensively on soils that are high in organic matter.

Except for livestock manure on some fields, the other major source of nitrates in soil is fertilizer nitrogen. Since fertilizer statistics are available only on a county-or state-wide basis, CBNS developed methods to convert these to the rate of fertilizer nitrogen applied per watershed acre. Multiple linear regression methods were used to determine the degree to which variations in stream nitrate levels are associated with differences in soil organic nitrogen (measured by proxy percent of land in row crops) and fertilizer nitrogen.* Because soil organic nitrogen was considered to exert little influence , CBNS dropped this variable and proceeded to develop an equation to predict stream nitrate concentrations with nitrogen fertilizer as a major independent variable. The dropping of soil organic nitrogen has important implications because it is closely correlated (Institute Doc. 74-38, page 20) with fertilizer nitrogen applied per watershed acre and the latter will then measure its own effects plus intercorrelated effects of soil organic nitrogen. Therefore, the net effect of fertilizer nitrogen on stream nitrogen concentrations will be overestimated and subsequently the effects of fertilizer control regulations will be overestimated. This is one of the basic faults in the CBNS study, which is recognized on pages 51-54 of Institute Document 74-38.

In this study water quality data in the spring (April through June) were paired with fertilizer nitrogen data for the previous year and row crop data for the previous year. After

*According to Table 2 (page 17) of Institute Document 74-38, the cube of row-crop acreage (F) explains more of the WQ (stream nitrate) variability than does nitrogen fertilizer cubed (E) from 1964 through 1968, whereas the opposite relationship exists from 1969 through 1972. Therefore, the choice of years included in this analysis (1969-1971) markedly affects the results obtained.

preliminary analysis, data for the three years 1969, 1970, and 1971 were studied in detail. 1970 was atypical in that a fungus, southern corn leaf blight, seriously reduced corn yields. Since the amount of corn produced and nitrogen taken up in 1970 was small in relation to fertilizer nitrogen applied, some of the latter was more likely to be free for leaching in subsequent years.

Nitrate concentrations in 22 Illinois streams were studied during the three years 1969 through 1971, making a total of 66 observations. Various linear and curvilinear mathematical expressions of the relationship between nitrogen concentrations in streams and fertilizer nitrogen used per watershed acre were studied. On the basis of these preliminary studies, the CBNS chose a curvilinear function, the cube of the rate of fertilizer nitrogen applied to introduce this variable into the overall predictive equation. It should be noted that the cube curve in Figure 3 (page 23), which was calculated from the points in Figure 2 (page 22) of Institute Document 74-38, is almost entirely dependent upon six of the 66 observations in this analysis; otherwise the relationship would be linear. Since the validity of the subsequent analyses and estimates are markedly influenced by the curvilinear relationship selected to express this fertilizer nitrogen variable, the findings are dependent upon a narrow data base in which six observations exert an inordinate influence. Therefore, caution should be exercised in expanding from such a narrow data base.*

Additional variables were tested and two of them were finally incorporated into the predictive equation: (1) stream discharge in relation to the long term average stream flow for the period of the year in question, and (2) urban population density as a proxy variable for nitrates from urban sources.

The predictive equation for this study is:

"$WQ = 0.31 + 5.48 \times 10^{-5} NF^3 + 1.20 \times 10^{-5} NF^3 \ FLO + 0.0047 \ URBPOP$,

where WQ is mean nitrate nitrogen in ppm in the April-June period, NF is the nitrogen fertilizer application rate per watershed acre, FLO is the average daily stream discharge rate for the April-June period divided by a yearly average daily discharge over 10 to 30 past years, and URBPOP is a measure of urban population density per square mile" (Institute Doc. 74-38, page 34). The above equation can be summarized in words as follows: "the average nitrate concentration of Illinois streams in the April-June period is a function of a constant term (0.31), plus a coefficient

*This and other deficiencies in the study were mentioned in review comments by the CBNS advisory committee for this study. See "Advisoı Committee Comments on Determination of Application Rates of Nitrogen Fertilizer to Achieve a Series of Nitrate Concentrations in Surface Waters and the Economic Effects Thereof," July 1974.

(5.48×10^{-5}) times the cube of nitrogen fertilizer use per watershed acre, plus a coefficient (1.20×10^{-5}) times an interaction term which is a product of the cube of nitrogen fertilizer use per watershed acre and the flow of the stream relative to a long term average, plus a coefficient (0.0047) times the density of urban population per square mile in the watershed." The coefficient of determination, $R^2 = .76$, is a measure of the proportion of the total variation in the dependent variable (river nitrate concentration) that is associated with the three independent variables. In this equation 76% of the variation in nitrate concentration in Illinois streams in the April-June period is associated with the three independent variables included herein or factors correlated with them.

Limitations on Nitrogen Fertilizer Estimated to Achieve Various Levels of Nitrate Concentrations in Surface Waters

The next step was to use the above equation to predict the stream nitrate concentrations that would be expected under specified values of the three independent variables. The predicted stream nitrate concentrations are not certain, but are expressed in terms of probability.

The predicted stream nitrate concentrations under different specified conditions are expressed in terms of percent failure rate, i.e., the rate of nitrogen fertilizer application (e.g., 150 pounds per acre) which would be required in order that a given stream nitrate concentration (e.g., 10 ppm) be exceeded no more than a given percent of the time.* "This is done by (a) assigning typical values to stream flow and urban population values in our predictive equation (a relative stream flow of 1.5, which is the 1946-1971 mean for Illinois streams, and an urban population density of 25 per square mile, which is the median for the sample watersheds in 1970), (b) taking the confidence interval for predictions of nitrate nitrogen concentration" from the predictive equation, "(c) using the confidence interval for predictions from this regression to calculate the mean nitrate nitrogen concentration that would allow 10 ppm to be exceeded with a given probability which corresponds to the failure rate, and (d) then calculating the nitrogen fertilizer use per watershed acre consistent with the mean nitrate nitrogen concentration by plugging nitrate concentration and the given values for stream flow and urban population into" the predictive equation and solving for fertilizer (Institute Doc. 74-38, page 36). The calculated rate of nitrogen application that results is expressed in the total acreage of the watershed, not the acreage to which fertilizer is applied.

*The current Illinois standard for public water supplies is 10 mg/l (or 10 ppm) of nitrate nitrogen; with a maximum value of 20 mg/l allowed for up to a total of 35 days per calendar year, of which no singl period shall be longer than 15 consecutive days.

Approximately 90% of the fertilizer nitrogen used in Illinois is applied to corn. "However, in the predictive equation, the relevant variable is the rate of nitrogen application per watershed acre. Hence, it is necessary to convert the value computed on the basis of watershed acreage to one computed on the basis of corn acreage. The relationship between the average rates of application of nitrogen per watershed acre to a limit set on the rate of application to corn acreage depends on two factors: (1) the fraction of the watershed area in corn and (2) the frequency distribution of rates of application of fertilizer nitrogen to corn when nitrogen use is uncontrolled" (Institute Doc. 74-38, page 37). The latter data for 1971 were obtained from the Doane Agricultural Service for five regions in Illinois: North, West-Central, East-Central, Southwest, and Southeast. "The average application of nitrogen per watershed acre consistent with a particular water quality standard can be converted to the average application per corn acre by dividing by the ratio of corn acreage to total acreage in an area to which the analysis is applied. In doing this we assume all nitrogen fertilizer is applied to corn." Table 2 shows the results of estimates, using the predictive equation, of the limits on the rate of fertilizer nitrogen applications to corn that would be required in order that concentrations of 10 ppm nitrate nitrogen in streams would be exceeded at various failure rates.

Table 2. Estimates of limits of nitrogen fertilizer applications to corn in order to meet a 10 ppm nitrate nitrogen water qualit standard with various probabilities of exceeding the standard for regions in Illinois.

Regions in Ill.	1971 fraction of land in corn	Fraction of land in corn	Maximum fertilizer N application rate (lbs N/acre corn) corresponding to percent time 10 ppm NO_3-N will be exceeded			
			1	5	20	50
North	.31	.50	90	110	130	160
		.45	110	130	170	Unreg.
		.40	120	170	Unregulated	
		.35	160	Unregulated		
		.30	Unregulated			
West-Central	.36	.50	100	130	170	Unreg.
		.45	120	160	Unregulated	
		.40	150	Unregulated		
		.35	Unregulated			
		.30	Unregulated			

Regions in Ill.	1971 fraction of land in corn	Fraction of land in corn	Maximum fertilizer N application rate (lbs N/acre corn) corresponding to percent time 10 ppm NO_3-N will be exceeded			
			1	5	20	50
East-Central	.39	.50	80	100	110	120
		.45	90	110	130	150
		.40	110	130	160	260
		.35	120	170	Unregulated	
		.30	170	Unregulated		
		.25	Unregulated			
Southwest	.21	.50	90	110	120	150
		.45	100	120	160	Unregulated
		.40	120	160	Unregulated	
		.35	160	Unregulated		
		.30	Unregulated			
Southeast	.16	.50	100	130	170	Unregulated
		.45	120	160	Unregulated	
		.40	150	Unregulated		
		.35	Unregulated			
		.30	Unregulated			

The estimated limits are markedly influenced by variations in the fraction of land in corn. For example, in East-Central Illinois the limit on the rate of nitrogen application which would be required in order that 10 ppm nitrate nitrogen stream concentrations be exceeded no more than 5% of the time is 110 lbs N/acre of corn when 45% of the land is in corn, or 170 lbs N/acre of corn when 35% of the land is in corn.

Table 2 indicates that different regions in Illinois would need different limits on the rate of fertilizer nitrogen application for a given fraction of land in corn to achieve the same stream nitrate concentration. For example, in the Southeast Region no limit on nitrogen fertilizer is needed (in order that stream nitrate nitrogen concentrations of 10 ppm not be exceeded more than 5% of the time) if 40% of the land is corn, whereas in the East-Central Region a limit of 130 lbs N/acre would be needed to achieve the same water quality with the same percent of the area in corn. For the 1971 fractions of land in corn, "if nitrogen fertilizer use was regulated on a regional basis, only East-Central Illinois would require regulation for the 10 ppm standard at the 1% failure rate" (Institute Doc. 74-38, page 43).

"If public policy is to be based on a program of limiting the use of nitrogen fertilizer, it must balance the hazards associated with high nitrate concentrations against the social cost of setting a limit on an important agricultural input. . . . The most effective means of controlling high nitrate concentrations in problem areas such as East-Central Illinois with a minimal effect on the overall agricultural output of the State is to set these limits on a regional or subregional rather than a statewide basis." Table 3 shows "that a regulation designed to achieve a given water quality in East-Centra Illinois when applied to the State rather than to the East-Central Region alone would affect twice as many farms, double the loss in corn output, and double the loss in gross income" (Institute Doc. 74-38, page 44).

Table 3. Percentage of farms affected, percentage change in cor output, and change in gross farm income due to a state wide limit of 130 pounds of nitrogen per acre and differentiated by regions in Illinois.

Item	Regions in Illinois					S
	N	W-C	E-C	SW	SE	
Percent of land in corn, 1971	31	36	39	21	16	
	Differentiated limits to meet a 10 ppr standard with a 5% failure rate					
Limit on N/acre corn	none	none	130	none	none	n
Percent of farms affected	0	0	37	0	0	
Percent reduction in corn output	0	0	1.1	0	0	
Decrease in gross income per affected farm ($)*	-	-	539	-	-	
Total decrease in gross farm income (mil $)*	0	0	6.6	0	0	
	Statewide limit of 130 lbs N/acre corr					
Percent of farms affected	23	24	37	23	13	
Percent reduction in corn output	0.6	0.7	1.1	1.6	0.7	
Decrease in gross income per affected farm ($)*	417	429	539	573	386	
Total decrease in gross farm income (mil $)*	1.5	1.4	6.6	2.4	0.6	

*The price used per bushel of corn is $1.25.

Economic Implications of Limitations on Fertilizer Use

The establishment of public policy relative to the stream nitrate problem involves an evaluation of the cost, to individuals and society, of any measures that might be introduced which reduce agricultural output. "In evaluating this cost it is important to determine how many farmers would be affected by the imposition of a given limit on the rate of fertilizer nitrogen application and how these limits would affect the consumption of nitrogen fertilizer (and hence the enterprises that depend on selling it), the output of corn, and the gross and net farm incomes" in the different agricultural regions in Illinois (Institute Doc. 74-38, page 55). The estimates in this subsection are based upon the relationships found in the previous two subsections. In this study, 1971 prices were used for corn ($1.25 per bushel) and nitrogen (5 cents per pound). Administrative or enforcement costs of possible controls were not considered.

Table 4 shows the estimated percentage of farms affected by regional limitations on the rate of nitrogen application to corn which would be required in order that the 10 ppm nitrate nitrogen water quality standard not be exceeded by specified percentages of time. East-Central Illinois would be much more severely affected than other regions, as would be expected from the estimates in Table 2. In fact, for the 1971 fractions of land in corn, only East-Central Illinois would be affected by a fertilizer nitrogen limitation needed to avoid exceeding the 10 ppm nitrate concentration in streams.

Table 4. Percentage of farms affected by the nitrogen fertilizer limits for the 10 ppm nitrate nitrogen standard by regions in Illinois

Regions in Illinois	1971 fraction of land in corn	Fraction of land in corn	Percent failure rates			
			1	5	20	50
North	.31	.50	57	51	23	8
		.45	51	23	5	
		.40	37	5		
		.35	8			
West-Central	.36	.50	38	24	6	
		.45	29	6		
		.40	14			
East-Central	.39	.50	76	66	59	52
		.45	71	59	37	22
		.40	59	37	18	1
		.35	52	12		
		.30	12			
Southwest	.21	.50	47	37	30	14
		.45	42	30	9	
		.40	30	9		
		.35	9			

Regions in Illinois	1971 fraction of land in corn	Fraction of land in corn	Percent failure rates 1	5	20	50
Southeast	.16	.50	36	13	3	
		.45	20	5		
		.40	9			

Table 5 presents estimates of the percentage decrease in nitroge fertilizer use by regions if controls were established on nitrogen fertilizer. East-Central Illinois would be affected most for any giv failure rate, which reflects the greater proportion of land in corn with associated nitrogen fertilization in that region. A 15% decreas in nitrogen use (3.5 tons per affected farm) is estimated for control corresponding to a 5% failure rate in East-Central Illinois if corn i planted on 40% of the land.

Table 5. Percentage decrease in nitrogen fertilizer use due to the nitrogen fertilizer limits for the 10 ppm nitrate nitrogen standard by regions in Illinois.

Regions in Illinois	1971 fraction of land in corn	Fraction of land in corn	Percent failure rates 1	5	20	50
North	.31	.50	33	21	11	4
		.45	21	11	3	
		.40	15	3		
		.35	4			
West-Central	.36	.50	25	13	4	
		.45	16	5		
		.40	7			
East-Central	.39	.50	43	30	25	19
		.45	36	25	15	10
		.40	25	15	8	1
		.35	19	6		
		.30	6			
Southwest	.21	.50	32	21	16	7
		.45	26	16	6	
		.40	16	6		
		.35	6			
Southeast	.16	.50	25	12	3	
		.45	15	4		
		.40	6			

The percentage decrease in corn output in any given cell in Table 6 is less than for the corresponding cell in Table 5 because reductions in fertilizer use which might be associated with controls occur along the upper, nearly level segment of the yield response curve.

Table 6. Percentage decrease in corn output due to the nitrogen fertilizer limits for the 10 ppm nitrate nitrogen standard by regions in Illinois.

Regions in Illinois	1971 fraction of land in corn	Fraction of land in corn	Percent failure rates			
			1	5	20	50
North	.31	.50	3.3	1.7	0.6	0.1
		.45	1.7	0.6	<0.05	
		.40	1.0	<0.05		
		.35	0.1			
West-Central	.36	.50	2.2	0.7	<0.05	
		.45	1.3	0.1		
		.40	0.2			
East-Central	.39	.50	8.6	4.3	2.9	1.8
		.45	6.3	2.9	1.1	0.4
		.40	2.9	1.1	0.2	0
		.35	1.8	0.1		
		.30	0.1			
Southwest	.21	.50	6.9	3.7	2.6	0.5
		.45	5.1	2.6	0.3	
		.40	2.6	0.3		
		.35	0.3			
Southeast	.16	.50	3.3	0.7	<0.05	
		.45	1.4	0.1		
		.40	0.4			

Table 7 shows the estimated change in net income per farm if nitrogen fertilizer use were controlled for the various conditions specified. Although the estimates indicate that nitrogen fertilizer controls would reduce net farm income under most circumstances, they also indicate that the changes in net income for higher failure rates and lower percentages of land in corn are positive. Even though these estimates suggest that unneeded fertilizer is applied where a relatively small percentage of the land is in corn, this is unlikely because most farmers take care to avoid fertilizing beyond the point of diminishing economic returns. In East-Central Illinois, if 40% of the land is in corn and a failure rate of 5% is acceptable, the average annual net income per affected farm would be reduced $186 if controls were placed on the rate of nitrogen fertilizer application.

Table 7. Changes in net income (in dollars) per farm for farms affected by the nitrogen fertilizer limits for the 10 ppm nitrate nitrogen standard by regions in Illinois.

Regions in Illinois	1971 fraction of land in corn	Fraction of land in corn	Percent failure rates 1	5	20	50
North	.31	.50	-554	-278	-100	+254
		.45	-278	-100	+378	
		.40	-146	+378		
		.35	+254			
West-Central	.36	.50	-479	-127	+345	
		.45	-329	+331		
		.40	+120			
East-Central	.39	.50	-1589	-797	-532	-319
		.45	-1176	-532	-186	+51
		.40	-532	-186	+180	+1072
		.35	-319	+318		
		.30	+318			
Southwest	.21	.50	-948	-596	-508	-106
		.45	-753	-508	- 20	
		.40	-508	-20		
		.35	-20			
Southeast	.16	.50	-353	-39	+273	
		.45	-163	+237		
		.40	+4			

OTHER CONSIDERATIONS

The CBNS study considered only one policy alternative to deal with the stream nitrate problem - limitations on rates of nitrogen fertilizer in combination with the percentage of land in corn. In addition to considering regulations for such a problem, other alternatives such as education, economic incentives, and public investment should be considered.

Dr. E.R. Swanson discussed some of the above alternatives and the kinds of information needed to evaluate them in "Non-Point Sources of Water Pollution, Problems and Policy Alternatives: Agriculture" during a workshop on March 20, 1975. Research and education are effective in identifying and applying farm practices (such as time and amount of fertilizer application, use of cover crops, etc.) that minimize adverse effects on water quality. Economic incentives might include excise taxes on nitrogen fertilizer, establishment of market "rights" to purchase fertilizer, etc. Although the tax system and the market "rights" system would involve less administrative cost than a regulatory system, monitoring would be necessary under a tax system to prevent imports from other areas. Public investment includes those investments which are not economically justifiable for individual users of water, but which can be justified by governmental units to achieve desired levels of water quality. For example, removal of excess nitrates from public water supplies is now feasible and is being done at Garden City, Long Island, New York. Ion exchange using resins would probably be most feasible for nitrate removal. The costs would be about 5 cents per 1000 gallons. Under some circumstances an alternate public water supply may be justified.

Dr. Swanson also indicated that in order to evaluate the economic implications of different public policy alternatives, information was needed concerning (1) the costs of adjustments in farm production related to the generation of potential pollutants, (2) the policy implementation costs, (3) the physical relationships between levels of on-farm pollutant generation and the various parameters of water quality at the locations of interest, (4) the functional relationship between these parameters and damage to the environment, including human health, and (5) the response of individuals in the system to various alternatives. Quantitative information is especially deficient concerning item (3) above. This inadequate physical data base makes it difficult to determine the validity of economic studies based upon such limited physical data. Although economic studies of several alternative policies have been made, the results are open to question because of the weak linkages between on-farm practices and water quality. This emphasizes the need of measuring the effect of nitrogen fertilizer rates on the nitrate content of surface and groundwater. More permanent water sampling stations are also needed to determine water quality status and trends, including nitrates.

The administrative feasibility or enforcement costs of possible controls on nitrogen fertilizer were not considered by CBNS (Institute Doc. 74-38, page 55). It would be difficult to fairly administer such controls on approximately 124,000 farms in Illinois or 38,000 farms (1969 Census of Agriculture) in the East-Central Region, especially since farms differ in soil types, slope, conservation practices, cropping patterns, and livestock interprises, and in alternative ways of accomplishing similar goals. Under such circumstances, regulations should not be adopted lightly.

Our food production system is very complex, with close multi-state and international linkages. Corn is currently being grown where it can be produced most economically, and East-Central Illinois has a prime economic advantage for corn production. For a given supply of corn, nitrogen fertilizer controls would shift production to less adapted areas, where costs would be greater and alternate problems, such as accelerated erosion on more sloping soils, would occur. Such a trade-off would not be in either the private or the public interest.

FINDINGS OF THE BOARD

On the basis of the record in this proceeding, the Board makes the following findings:

1. The nitrate problem is not a statewide problem in Illinois with our water quality standard of 10 ppm nitrate nitrogen (20 ppm is permitted for short periods). The nitrate problem in streams is concentrated in East-Central Illinois, with lesser problems in the West-Central and Northern Regions. Streams in southern Illinois are low in nitrates, but the water in some shallow wells on farms is high in nitrates. These high nitrates in farm wells are ascribed to livestock wastes and septic fields rather than to fertilizer.

2. Differences among regions in the intensity of nitrogen fertilizer use and the percentage of land in corn lead to differences between regions in the estimates of limits on the rate of application of fertilizer nitrogen to corn which would be required to reduce stream nitrate concentrations to specified levels.

3. Estimates of these limits are more sensitive to the intensity of fertilizer use and the percentage of land in corn than they are to variations in the other two factors (relative stream flow and the density of urban population per square mile) that were included in the study. However, the omission of soil organic matter nitrogen from the analyses will probably overestimate the effects of nitrogen fertilizer on water quality and the effects of possible nitrogen fertilizer controls.

4. If nitrogen fertilizers were regulated, for example, in East-Central Illinois, corn production and net income would be reduced on most farms in the region.

5. The relationship between nitrogen fertilizer practices on farms and nitrate concentrations in streams is not adequately enough established to adopt regulations on nitrogen fertilizer use at this time. Special attention should be given to measuring these relationships.

6. Information is too meager to determine whether alternatives such as economic incentives or public investments should be used to control nitrate concentrations in water from streams. There is very little information on the administrative feasibility or enforcement costs of possible controls on nitrogen fertilizer. On the basis of available information on the above topics, the alternative of municipal water treatment, and the uncertainties as to the biases in the predictive equation in the CBNS study, the Board finds that a regulation on nitrogen fertilizer is not justified at this time because the likely improvement in water quality does not outweigh the probable disruption of our food supply.

7. Special attention should be given to research and education programs to reduce the nitrate concentrations in streams in East-Central Illinois.

ORDER

IT IS THE ORDER OF the Illinois Pollution Control Board that:

1. The regulation of nitrogen fertilizer to control nitrates in Illinois streams is not justified at the present time.

2. The proceeding in R71-15 is hereby concluded.

I, Christan L. Moffett, Clerk of the Illinois Pollution Control Board, hereby certify the above Opinion and Order were adopted on the 29th day of September, 1975 by a vote of 4-0.

Christan L. Moffett, Clerk
Illinois Pollution Control Board