ILLINOIS POLLUTION CONTROL BOARD
March 30, 1978

IN THE MATTER OF:	)	
PROPOSED FINAL	)	
AMENDMENT TO CHAPTER 3,	)	
WATER POLLUTION REGULATIONS;	)	R77-6
Rule 402.1, an Exception to	)	
Rule 402 for Certain Ammonia	)	
Nitrogen Sources	)	

OPINION OF THE BOARD (by Mr. Young): (PROPOSED FINAL)

On March 28, 1977, the Pollution Control Board authorized public hearings on an Environmental Protection Agency proposal designated as R77-6 to amend Chapter 3 of the Board's Water Pollution Regulations by the addition of a proposed Rule 402.1. The Rule 402.1 would establish an exception to Rule 402 until December 31, 1978, or at a date established by NPDES permit, for ammonia nitrogen discharges from small facilities having limited influent ammonia loading and for larger sources, allow the discharge of effluent containing a concentration of no more than 4.0 mg/l of ammonia nitrogen during the months of November through March. The exemption provided by proposed Rule 402.1 would terminate June 30, 1981.

Notice of the Agency proposal was published in the Environmental Register #145 on April 11, 1977. Public hearings pursuant to Section 28 of the Environmental Protection Act were held on the proposed rule in Springfield on May 10, 1977, and in Chicago on May 13, 1977, and a study of the economic impact of the proposal by the Institute for Environmental Quality was filed with the Board on June 27, 1977. As required by Section 27(b) of the Act, two hearings were held on the economic impact of the proposal; on September 9, 1977, in Chicago, and in Springfield on September 13, 1977. At the final hearing, the Hearing Officer ordered the record closed fifteen days after the filing of the final transcript; final transcript was filed November 17, 1977, the record was closed December 5, 1977. There were two principal additions made to the record after the final hearing. On October 21, 1977, the Illinois State Water Survey submitted a pre-publication copy of a report ISWS-77-RI85 entitled Acute Toxicity of Residual Chlorine and Ammonia to Some Native Illinois Fishes by Donald P. Roseboom and Dorothy L. Richey (hereinafter referred to as Roseboom and Richey). The Agency submitted operating data in the form of NPDES discharge monitoring reports from the MSDGC John E. Egan water reclamation plant on October 25, 1977.

THE PROPOSED RULE

The language of the Agency's proposed rule change filed with the Board on May 3, 1977 (Exh. 2), is as follows:

> "Rule 402.1 Exceptions to Rule 402 (Ammonia Nitrogen)
>
> a) Rule 402 shall not apply to that portion of Rule 203(f) pertaining to ammonia nitrogen for any effluent from sources in existence on April 1, 1977, which sources have an untreated ammonia load not exceeding 60 pounds per day and which sources do not require upgrading to meet other provisions of this Chapter.
>
> b) Rule 402 shall not apply to that portion of Rule 203(f) pertaining to ammonia nitrogen for any effluent during the months of November through March. During that period no effluent which alone or in combination with other sources might cause a violation of that portion of Rule 203(f) pertaining to ammonia nitrogen shall exceed 4.0 mg/l of ammonia nitrogen.
>
> c) Compliance with the provisions of Rule 402 as it applies to ammonia nitrogen shall be achieved by December 31, 1978, or such other date set forth in an Agency approved NPDES compliance program.
>
> d) After July 1, 1981, the exemptions provided in this Section 402.1 shall terminate.

James B. Park, P.E., Supervisor of the Standards Unit, Division of Water Pollution Control, presented testimony describing and explaining the basic elements of Rule 402.1 and the considerations underlying the Agency proposal (R. 9-11; 59-61). (*See Note.)

*Note

There were four hearing transcripts taken in this proceeding. In the transcripts of the first two (May 10 and 13, 1977) hearings, the pages are consecutively numbered 1 through 169. The pages of the third transcript taken September 9, 1977, are numbered 75 through 118; in the fourth transcript (September 12, 1977) the pages are numbered 40 through 74. To avoid confusion, citations to the May 10 and May 13 transcripts will be prefixed by R, followed by the page number. The page numbers of the transcripts of September 9 and September 12 will be preceded by an S and T, respectively; hence a citation S._ _ _ will refer to the record taken September 9 and T._ _ _ to September 12.

The proposed rule would establish, where none now exists, an interim ammonia nitrogen effluent limitation until July 1, 1981, of 1.5 mg/l April through October and 4.0 mg/l November through March for sources having an influent ammonia nitrogen loading in excess of 60 pounds per day, or for any source, not in existence on April 1, 1977, irrespective of loading. Compliance with the interim effluent limitations is proposed to be achieved by December 31, 1978, or such other date as established by NPDES (National Pollutant Discharge Elimination System) permit. An exemption until July 1, 1981, is proposed for sources having a daily influent ammonia nitrogen loading of less than 60 pounds if the source was in existence on or before April 1, 1977, provided that such source does not require facilities upgrading to meet any other requirement of Chapter III.

Existing sources subject to Rule 406, which limits ammonia nitrogen discharges to 2.5 mg/l April through October and 4.0 mg/l November through March for domestic wastewater sources and to 3.0 mg/l for other sources discharging to the waters named therein, are not included in the proposed rule. No discharges which are or may be subject to the limitations of Rule 406 are or are intended to be affected by the adoption or the termination of the proposed Rule 402.1. The proposal does not and is not intended to supercede or alter Rule 203(f) or Rule 206(c) which establish ammonia nitrogen water quality standards in General Use Waters and Lake Michigan.

REGULATORY BACKGROUND

Ammonia Nitrogen Water Quality Standards were added to the Board's Water Pollution Regulations on March 7, 1972 (3 PCB 755) at which time the Board stated:

> "In large part today's draft is simply a codification of existing water quality standards and associated provisions that are now scattered throughout a number of separate regulations that we inherited from the Sanitary Water Board."

Rule 203(f) established a general water quality standard, not to be exceeded, for ammonia nitrogen (as N) of 1.5 mg/l. Rule 206 established a water quality standard for Lake Michigan for ammonia nitrogen of 0.02 mg/l.

In adopting Rule 203(f) the Board said (at 3 PCB 759) regarding ammonia nitrogen:

> "The present SWB-8 standard is 2.5 mg/l which the Green Book (supra) says is acutely toxic to fish. The earlier 1.0 proposal was based

> upon a Minnesota standard. While the toxicity of ammonia is pH dependent, the Green Book recommends a limit of 1.5 mg/l, and that is here adopted."

In regard to the Lake Michigan ammonia nitrogen standard of 0.02 mg/l established by Rule 206 the Board only stated (at 3 PCB 764) that:

> "Certain parameters taken from existing standards are preserved to require this high quality lake to remain especially clean for esthetic and recreational purposes, in accordance with the important non-degradation policy."

The existing standard referred to above, Rule 1.01 of SWB-7, established a Lake Michigan open water ammonia nitrogen standard of 0.02 mg/l annual average not to exceed a daily average of 0.05 mg/l; Rule 1.02 of SWB-7 set a Lake Michigan shore water standard of 0.05 mg/l annual average not to exceed a daily average of 0.12 mg/l. Since the standard of SWB-7 in Rule 1.01 was an annual average, the Lake Michigan standard established by Rule 206 would appear considerably more than a preservation of the SWB standard.

The relationship between the water quality standards and effluent limitations of Chapter III is established by Rule 402, adopted January 6, 1972, which reads as follows:

> "In addition to the other requirements of this Part, no effluent shall, alone or in combination with other sources, cause a violation of any applicable water quality standard. When the Agency finds that a discharge that would comply with effluent standards contained in this Chapter would cause or is causing a violation of water quality standards, the Agency shall take appropriate action under Section 31 or Section 39 of the Act to require the discharge to meet whatever effluent limits are necessary to ensure compliance with the water quality standards. When such a violation is caused by the cumulative effect of more than one source, several sources may be joined in an enforcement or variance proceeding, and measures for necessary effluent reductions will be determined on the basis of technical feasibility, economic reasonableness, and fairness to all dischargers."

In the adopting Opinion, the Board said (at 3 PCB 405):

> "402 Violation of Water Quality Standards. The numerical effluent standards adopted today are

> intended as basic requirements that should be met everywhere as representing ordinary good practice in keeping potentially harmful materials out of the waters. In some cases, because of the low volume of the receiving stream or the large quantities of treated wasted discharged, meeting these standards may not suffice to assure that the stream complies with water quality standards set on the basis of what is necessary to support various water uses. In such cases the very nature of water quality standards requires that additional measures be taken beyond those required by ordinary good practice to reduce further the discharge of contaminants to the stream. This would not be so if effluents were all required to be as clean as the receiving stream, but in recognition of economic hardship we have refrained from imposing such a requirement across the board. What additional measures are required can be determined only on the basis of more detailed consideration of each stream in accordance with the statutory requirement that different needs may dictate different standards. Rule 402 states the principle that discharges causing violations of the water quality standards are forbidden, as was the case under the earlier regulations, and states basic considerations for determining which of a number of contributors to an overloaded stream must take measures to abate the problem. At the Agency's request an additional sentence has been added to spell out the Agency's responsibility."

Rule 406, which was adopted January 6, 1972, established an ammonia nitrogen effluent limitation for discharges to the Illinois River, the DesPlaines River downstream of its confluence with the Chicago River System, the Chicago River System, and the Calumet River System. Rule 406 provides that discharges to those waters named above by sources having an untreated ammonia waste load of more than 50,000 P.E. shall not contain more than 2.5 mg/l of ammonia nitrogen (as N) April through October or 4 mg/l at other times. No other ammonia nitrogen effluent limitation has been established for waters other than those listed in Rule 406 and none were established for sources having an influent ammonia nitrogen waste load of less than 50,000 P.E.

In the Opinion (3 PCB 401) adopting the rule, the following comments appear beginning on page 406:

> "406 Nitrogen. The evidence is clear that for too long the oxygen demand exerted by ammonia in domestic wastes had been overlooked in the

emphasis on reduction of five-day BOD. The State Water Survey has conclusively shown that reduction of ammonia from the larger sources feeding the Illinois River is necessary if existing standards for dissolved oxygen, essential to an adequate fish population, are to be met. This is exactly the sort of testimony that is required, as discussed in connection with Rule 402 above, in order to assure that the water quality standards are complied with. There was extensive testimony as to the availability of methods for reducing ammonia in effluents, and although several witnesses believed the technology was not sufficiently proven in actual operation, we are convinced that nitrification can be satisfactorily accomplished for a reasonable price by a second stage of biological treatment. The testimony of Edwin Barth and of Dr. Clair Sawyer, both of whom are intimately familiar with actual facilities for nitrification, is particularly effective on this point. The Metropolitan Sanitary District, which is principally affected by our proposal, is committed to employing nitrification. Although Dr. Sawyer's testimony establishes that an effluent of 2.5 mg/l can be achieved even in winter by constructing a large enough tank, we have accepted the Sanitary District's suggestion of a slightly relaxed winter standard in order to save costs in light of the Water Survey's assurance that such an effluent will not jeopardize oxygen levels in the Illinois River.

We do not in this record have sufficient information to enable us to set ammonia effluent standards for other waters, although the possibility of setting them on the basis of dilution ratios, as in the case of BOD, is worth exploring in future hearings. It is likely that ammonia reductions elsewhere will prove necessary in order to meet stream standards either for oxygen or for ammonia itself, which in relatively low concentrations may be toxic to fish. The Agency should of course consider such questions in passing on individual permit applications. But we think it appropriate not to delay adoption of the standards we know to be necessary in the Illinois River while determining what standards are necessary elsewhere."

Rule 406 was amended on June 28, 1973, in R72-4 by adding the provision that sources discharging to any of the waters listed in 406 and having an untreated waste load which could not be computed on a population equivalent basis and discharging ammonia nitrogen in excess of 100 pounds per day, could not discharge an effluent containing more than 3.0 mg/l of ammonia nitrogen after December 31, 1974. This amendment did nothing more than provide an additional clarification of the definition of a source subject to the effluent limitations of Rule 406; for either case, the threshold for applicability of the rule is established by a discharge of 100 pounds per day of ammonia nitrogen, however calculated.

NEED FOR THE PROPOSED REGULATION

Through the operation of Rule 402, domestic wastewater treatment facilities not subject to Rule 406 and discharging to intermittent or low flow streams must be designed to provide for ammonia nitrogen reduction to 1.5 mg/l to preclude violation of the water quality standard of Rule 203(f). The Agency has identified at least 1479 sources which require ammonia nitrogen reduction under the present regulations (Exh. 1A3). Of this total of 1479 sources, 976 are facilities designed to serve fewer than 1000 P.E. and 214 serve fewer than 2500 P.E. (Exh. 1A10, Table 3). In all instances, in order to insure compliance with the water quality standard, breakpoint chlorination of the effluent is required, a practice which the Agency believes is beyond operational feasibility at the small facilities, unreasonably expensive, and environmentally unsound (Exh. 1A6-12; R. 135).

Table 3-3 of Exhibit 7 provides a breakdown by discharger type of 1489* sources which require further ammonia nitrogen reduction:

Discharger Type	Number
Municipalities	647
Schools	221
State Parks & Campgrounds	64
Service Stations	11
Trailer Parks	142
Commercial	45
Recreational Facilities	101
Nursing Homes	34
Agricultural	11
Municipal Facilities	55
State Highway Dept.	23
Motels	19
Residential	58
Miscellaneous	58
TOTAL	1489

*Note: There is an unexplained difference of 10 between the Agency total of 1479 and the total of 1489 reported in Exhibit 7. The discrepancy occurs in Category #2, Schools & Other.

Table 3 of Exhibit 1A breaks the 1479 sources into two categories, category #1 - Municipalities and category #2 - Schools & Other, by plant design capability in population equivalents (P.E.).

Plant Design P.E.	Category #1 Municipalities	Category #2 Schools & Other
less than 1000	179	797
1000-2499	196	18
2500-4999	100	6
5000-9999	70	7
10000-99999	86	4
more than 100,000	16	-
	647	832

Based upon this information, approximately 1190 of these 1479 facilities will not receive a daily average influent loading of 60 pounds of ammonia nitrogen.

AMMONIA REMOVAL

Ammonia is a colorless gas consisting of nitrogen and hydrogen which reacts with water to form an aqueous solution of ammonium hydroxide. When sufficient ammonia is dissolved in water, a chemical equilibrium results which contains un-ionized ammonia, and ammonium and hydroxide ions. A simplified expression of the equilibrium is:

$$NH_3 + H_2O \rightleftharpoons NH_3 \cdot H_2O \rightleftharpoons NH_4^+ + OH^-$$

where $NH_3 \cdot H_2O$ represents the un-ionized ammonia; NH_4^+, ammonium ion; and OH^-, hydroxide ion. For the purpose of this opinion, NH_3 will be used to indicate dissolved un-ionized ammonia, NH_4^+ to designate the ammonium ion and the sum of the two as total ammonia or ammonia nitrogen.

Ammonia can be found as a natural constituent in most waters, usually as a decomposition product of organic material containing nitrogen. Ammonia is a common constituent of domestic sewage; sources of ammonia may also include rain and dust fall as well as anthropogenic activity such as agriculture and industry. Much of the ammonia present in surface waters results from the effluent discharged from wastewater treatment facilities. In its several states, and as a source of nitrogen, ammonia can be toxic, may cause excessive growth of algae, reduce dissolved oxygen and may react with other elements to form other undesirable or toxic compounds in water. The nitrogen in ammonia can be substantially removed during wastewater treatment by biologic or physical-chemical processes or combinations thereof.

Biologic treatment of domestic wastewater is virtually universally practiced and it has been demonstrated that cost-effective biological treatment processes, such as activated sludge,

trickling filters, recirculating intermittent sand filters and natural or aerated stabilization ponds, can be designed which are capable of nitrifying the wastewater and thereby reducing effluent ammonia nitrogen concentrations to levels of 1.5 mg/l during warm weather. The process of nitrification, however, is temperature dependent; the rate of nitrification decreases as the temperature decreases. It is not cost-effective to design biological processes capable of removing ammonia nitrogen to 1.5 mg/l from very cold domestic wastewater. In Illinois, facilities treating domestic wastewater utilizing the types of biologic processes which yield effluent concentration of 1.5 mg/l during the warm months are usually incapable of consistently reducing ammonia nitrogen concentrations below 4.0 mg/l during cold weather (Exh. 1A4; R. 23, 45-46, 66-67, 72-73, 120-123, 240-241; Exh. 3 1-13).

As mentioned above, there are physical-chemical processes for nitrogen removal; the three candidate physical-chemical processes suggested are ammonia stripping, selective ion exchange and breakpoint chlorination. Conceptually at least, these processes are initially attractive because they remove the ammonia directly, are not subject to the biologic upset and operational uncertainty of the biologic-treatment processes and require less tankage and hence less space than biologic processes (Exh. 1H, 1).

Ammonia stripping and selective ion exchange are not suitable or cost-effective processes for ammonia removal in Illinois. Ammonia stripping is more sensitive to cold temperatures than the biologic-treatment processes. Both ammonia stripping and ion exchange are energy intensive, both require sophisticated automated process control for effective operation; neither process has been demonstrated over a range of treatment applications, and there is a question whether or not either could consistently meet a 1.5 mg/l standard without a polishing operation following the process (Exh. 1A, 5-6; Exh. 1H, 21; Exh. 7, 32; R. 26, 104).

BREAKPOINT CHLORINATION

The breakpoint chlorination process for removal of ammonia nitrogen from water, very generally stated, proceeds as follows:

As chlorine, as chlorine gas (Cl_2) or as sodium hypochlorite (NaOCl), is added to water, hypochlorous acid (HOCl) and hypochlorite ion (OCl^-) are formed. If the water contains ammonia nitrogen, as is the case with domestic wastewater, the ammonia reacts with the hypochlorous acid to form monochloramine (NH_2Cl), dichloramine ($NHCl_2$) and nitrogen trichloride or trichloramine (NCl_3), depending upon the amount of chlorine added and pH, with the monochloramine the most usual formation in domestic wastewater treatment. As additional chlorine is added, the chloramines are converted to nitrogen gas; maximum

conversion is achieved, and ammonia removed, when the total chlorine residual is at minimum, or breakpoint; hence the process name, breakpoint chlorination. The term total residual chlorine is used to describe the sum of free chlorine (chlorine, hypochlorous acid and hypochlorite ions) and combined residual chlorine (chloramines) in water. Chloramines are believed to be slightly less toxic to fish than free chlorine, however, the difference is apparently slight and water quality criteria, such as the U.S. Environmental Protection Agency's Quality Criteria for Water, EPA-440/9-76-023, (the "Red Book"), suggest a water quality criterion of 10.0 micrograms per liter for total residual chlorine. The Illinois State Water Survey Report ISWS-77-RI85, Roseboom & Richey, p19, concluded that for the protection of the fish investigated (bluegill, largemouth bass, channel catfish) residual chlorine should not be detectable in Illinois streams; the permissible concentration for residual chlorine for the protection of channel catfish determined by them was about 9 micrograms per liter which closely corresponds to the Red Book criterion.

A simplified description of the breakpoint chlorination process, together with some functional disadvantages of the process were introduced into the record by the Agency in Group Exhibit 1 (Exh. 1, 4-6):

1. Chlorine, either in the form of chlorine gas or sodium hypochlorite, is introduced into and thoroughly mixed with ammonia containing wastewater.

2. The chlorine reacts with the ammonia and produces, under different dosages and pH conditions, the end products of monochloramine, dichloramine, nitrogen trichloride, hydrochloric acid, and free nitrogen.

3. The acid produced by these reactions reacts with the carbonate alkalinity normally present in domestic wastewater and is neutralized.

4. Because chloramines are toxic to aquatic life, and because nitrogen trichloride produces unpleasant odors, it is necessary to dose with chlorine at fairly high rates in order to cause the ammonia to be converted completely to nitrogen gas.

5. It is necessary to carefully control the dosage rate and the pH of the wastewater in order to cause the reaction to go to completion.

6. Since it is necessary to overdose with chlorine in excess of the stoichiometric ratio to drive the chemical reaction, a substantial chlorine residual exists after breakpoint chlorination. This residual is high enough to be toxic to aquatic life.

7. Dechlorination is most practically accomplished by sulfur dioxide feeding in a suitable reactor, but it has the disadvantage of producing sulfuric acid, usually requiring pH correction by feeding in a base to neutralize the acid.

8. The functional disadvantages of the breakpoint chlorination/dechlorination process are as follows:

    a) The process requires the use of sophisticated automated chemical feed equipment to assure reasonable control.

    b) Failure of any part of this system may cause the production of chemical byproducts which are more toxic than the initial ammonia concentrations.

    c) The process must be manned and monitored on a 24-hour a day basis in order to assure day-in day-out process reliability.

    d) The process is inherently energy intensive.

In amplification of the disadvantages summarized in paragraph 8 above, the Agency concluded that control of the breakpoint chlorination process for ammonia reduction is not operationally feasible at most of the 1479 treatment plants in categories 1 and 2 as described on page 8 above. In support of this conclusion, the Agency cited the following:

a) natural fluctuations of diurnal flow and of the chlorine demand make it necessary to install intricate automated flow measurement devices with automated responsive chlorine feed controls to compensate for pH, chlorine residual and ammonia concentrations;

b) lack of demonstrated reliability for such automated equipment under field conditions is expected to be a major problem, including downtime and costs;

c) the toxicity of residual chlorine from the process requires installation of automated sulfur dioxide feed equipment to assure adequate dechlorination;

d) the dechlorination process requires precise automated monitoring to prevent the occurrence of conditions toxic to fish from excess sulfur dioxide; and,

e) maintenance and operation of equipment for ammonia nitrogen reduction by breakpoint chlorination (and subsequent dechlorination) is beyond the capability of currently available plant operating personnel because of the preponderance of small, low-operating budget facilities typified by plants having a capacity of less than 0.25 million gallons per day which comprise more than 90% of the total treatment facilities in the State (Exh. 1A, 12; R. 25-31, 85-91, 96-98).

Other potential disadvantages of the breakpoint chlorination process revealed by the record are the substantial increase in total dissolved solids which is inherent in the process; the potentially very hazardous halogenated organic compounds (organochloramines) which can be formed during the process; and the depression of dissolved oxygen in the wastewater as a result of dechlorination using sulfur dioxide (Exh. 1A, 7; Exh. 1E, 1-5; Exh. 1F, 2-5; 10-13; 44-49; Exh. 1H, 17-21).

The Agency presented, in Exhibits 1A and 1B, estimates of the capital expenditures and operation and maintenance costs which would result from the use of breakpoint chlorination as a backup process to biologic ammonia removal. These costs were estimated utilizing the USEPA publication, "A Guide to the Selection of Cost-Effective Wastewater Treatment Systems," July 1975, for the 1479 installations in Illinois (excluding MSDGC and industrial) requiring ammonia nitrogen reduction. Capital costs to provide the backup breakpoint chlorination for the 1479 installations were estimated by the Agency to total $185.6 million.

The Agency estimate of annual operation and maintenance costs (excluding capital amortization) of the backup processes is approximately $8.8 million, exclusive of MSDGC and industrial plants, which they estimate would result in unit costs ranging from $1.40 per connection per month for a plant of 600 P.E. (200 connections) to $1.18 per connection per month for a 10,000 P.E. plant (3333 connections).

The breakdown of the costs estimated by discharger category taken from Exhibits 1A, 8 and 1A, 10 are as follows:

CAPITAL COST OF BREAKPOINT CHLORINATION
FOR BACKUP AMMONIA NITROGEN REMOVAL

Plant Design P.E.	Unit Plant Capital Costs $1000's	Category #1 - Municipalities No. Plants	Capital Costs Millions $
Less than 1000	60.0*	179	10.74
1000-2499	95.87	197	18.79
2500-4999	187.35	100	18.73
5000-9999	290.97	70	20.30
10000-99999	439.59	86	37.80
100,000 +	1,561.58	16	24.98
TOTAL - Category #1		647	$131.32

Plant Design P.E.	Unit Plant Capital Costs $1000's	Category #2 - Schools & Other No. Plants	Capital Costs Millions $
Less than 1000	60.0*	797	47.8
1000-2499	95.87	18	1.7
2500-4999	187.35	6	1.1
5000-9999	290.97	7	2.0
10000-99999	439.59	4	1.7
100,000 +	1,561.58	0	-
TOTAL - Category #2		832	$54.3

Total Capital cost for Categories #1 and #2 = $185.6 million

*Scaled down by factor of 0.628

From Exh. 1A, 8 - Table 2

OPERATION AND MAINTENANCE COST OF
BREAKPOINT CHLORINATION FOR AMMONIA NITROGEN REMOVAL
(4 months of operation per year)

Plant Design P.E.	Unit Plant Annual O & M $1000's (÷4)	Category #1 - Municipalities No. Plants	O & M Costs Millions $
Less than 1000	10.17*	179	.6
1000-2499	12.79	196	.83
2500-4999	19.68	100	.65
5000-9999	20.78	70	.69
10000-99999	47.32	86	1.36
100,000 +	323.57	16	1.72
TOTAL - Category #1		647	$5.85

Plant Design P.E.	Unit Plant Annual O & M $1000's (÷4)	Category #2 - Schools & Other No. Plants	O & M Costs Millions $
Less than 1000	10.17*	797	2.7
1000-2499	12.79	18	.08
2500-4999	19.68	6	.04
5000-9999	20.78	7	.07
10000-99999	47.32	4	.06
100,000 +	323.57	-	-
TOTAL - Category #2		832	$2.95

Total O & M cost for Categories #1 and #2 = $8.8 million

*Scaled down using a factor of 0.628

From Exh. 1A, 10 - Table 3

ECONOMIC IMPACT

The Illinois Institute for Environmental Quality performed a study on the economic impact of the proposed regulation pursuant to §6(d) of the Act. This study, "Economic Impact of a Proposed Change in Ammonia Effluent Standards, R77-6," IIEQ Doc. No. 77/18, was filed with the Board on June 27, 1977, and was introduced into evidence as Exhibit 7 at the September 9, 1977, hearing in Chicago.

In addition, Exhibit 7A, "Points for Consideration," was introduced at the September 12, 1977, hearing and makes certain corrections to Exhibit 7. (*See Note.) By the Act, the Economic Technical Advisory Committee reviewed the economic impact study prior to the filing of the study with the Board and, on review, found the report to be generally responsive to the requirements of Section 6 of the Act.

Ms. Linda L. Huff, BS Ch.E, MBA, the economic impact study contractor for IIEQ study, summarized the study (S.81-98) and concluded:

> "On the basis of the economic impact and benefit cost analysis of the proposed IEPA exception to the existing effluent standards, adoption of this proposal is justified. The severe economic impact on small commercial operations, schools, and municipalities with little gained in terms of environmental improvement suggests an exemption for dischargers less than 2500 PE is a cost effective policy. Additional time for the compliance of larger facilities removes the potential loss of federal and state funds for municipal construction and provides for technological development. The benefits foregone by granting this exception to regulation are less than the costs incurred by society and the dischargers. Therefore, the proposed regulatory exception is an economically acceptable plan.

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*Note

Certain arithmetic errors exist in Exhibit 7A, 2. The product listed in the first row should be $2,440,000 and the product listed in the third row should be $712,800. Hence the sum of the products should be $8,049,700. Tables 2-2 and 5-8 of Exhibit 7 should be corrected, as p. 1 of Exhibit 7A suggests, but corrected using proper values. The values in parentheses in the "Annual Costs" column of these tables should be $26.2 for row 1 (biological nitrification, $18.2; breakpoint chlorination, $8.0) and $13.9 for rows 2 and 3 (biological nitrification, $9.3; breakpoint chlorination, $4.6). The above renders the cost columns of Tables 2-3 and 5-9, "Present Value of Benefits and Costs" less useful; the present values have not been recomputed since (1), the regulation self-destructs in four years and (2), twenty years is a totally arbitrary time period.

> In fact, it appears that a stronger proposal may be warranted. Unless a water quality standard modification for intermittent streams is contemplated, the smaller dischargers will be severely impacted in 1981. The incremental costs associated with their compliance far exceed the incremental gains achieved. For larger treatment plants it may be difficult to initiate and complete treatment facilities within the time frame outlined by IEPA. Certainly the exception proposed will alleviate immediate compliance and funding problems. Consideration of the practical logistics in obtaining such significant auxiliary treatment facilities is important in the final analysis of the economic impact." (S.92-93; Exh. 7, 13).

Review of the economic impact study (Exh. 7; Exh. 7A), the economic analysis presented by the Agency (Exh. 1A, 7-11; Exh. 1B, 1-8) and the testimony in the record (S.81-206; T.67-69) reveals nothing in contradiction to the conclusions of the economic impact study and the economic impact study supports the cost figures estimated by the Agency. It should be noted that the costs developed were for the cost of providing breakpoint chlorination only as a backup to biological removal of ammonia. The cost of ammonia removal by biologic treatment was not compared to the cost of ammonia removal by breakpoint chlorination either by the economic impact study contractor or by the Agency. Nor is it necessary since the regulation proposed does not require a judgment as to the relative economic performance of either system. In view of the large number of small plants within the lagoon exemption of Rule 404(c) and the fact that some 90% of the treatment facilities in the state are designed to serve a capacity of less than 0.25 MGD, there is little question that biologic treatment as the primary means for ammonia nitrogen removal will continue. Dr. Thomas E. Wilson, who participated in the EPA technology transfer program on nitrogen control and has published a number of papers on nitrogen control, stated that the state of the art for nitrogen control is biological nitrification (R. 70).

In consideration of the economic impact of the proposal, the Board notes differences between the estimate provided by Dr. Thomas E. Wilson of Greeley & Hansen (Exh. 7, Appendix B, 83) and the estimate provided by the Agency (Exh. 1B, 6, Table 4) of the cost of breakpoint chlorination/dechlorination as a backup for ammonia nitrogen removal; the differences were utilized in the economic impact study to provide a range of costs and the conclusions reached are valid using either estimate of costs.

WATER QUALITY CONSIDERATIONS

The present Rule 203(f) water quality standard of 1.5 mg/l was based, as indicated previously, on the recommended limit of the Green Book (3 PCB 759). The "Green Book," published in 1968 by the Federal Water Pollution Control Administration, U. S. Department of the Interior, has been superceded by the "Red Book" published by the U. S. Environmental Protection Agency and titled Quality Criteria for Water. The water quality criterion for ammonia set forth on page 16 of the Red Book is 0.02 mg/l (as un-ionized ammonia) for freshwater aquatic life. The Red Book (at page 21) concludes that:

> "Levels of un-ionized ammonia in the range of 0.20 to 2 mg/l have been shown to be toxic to some species of freshwater aquatic life. To provide safety for those life forms not examined, 1/10th of the lower value of this toxic effect range results in a criterion of 0.020 mg/l of un-ionized ammonia. This criterion is slightly lower than that recommended for European inland fisheries (EI FAC, 1970) for temperatures above 5°C and pH values below 8.5. Measurement of values of total ammonia for calculation of values in the range of 0.020 mg/l NH_3 is well within current analytical capability."

The philosophy of the Red Book is that the criteria presented therein, appropriately modified to take account of local conditions, form a basis for judgment in establishing water quality standards. The local conditions to be considered include actual and projected uses of the water, natural background levels of particular constituents, the presence or absence of sensitive important species, characteristics of the local biological community, temperature and weather, flow characteristics, and synergistic or antagonistic effects of combination of pollutants (Exh. 8, 7).

The Consulting Engineers Council of Illinois, through the testimony and exhibits presented by Mr. M.D.R. Riddell and Dr. T.E. Wilson, both of Greeley & Hansen, urged the adoption of a variable concentration ammonia water quality standard such as recommended for European inland fisheries which is discussed in the Red Book and which the Consulting Engineers Council of Illinois had urged in 1973 in R73-3 and 73-4 and which CEC/I had submitted to the Board in November, 1972 (R. 77; Exh. 3, 3, 10-15, 20, 22-26).

There is wide-spread agreement that the dissolved un-ionized ammonia (NH_3) is the toxic constituent in aqueous solutions of ammonia and that the percentage of NH_3 increases with increasing temperature and alkalinity. Estimates of the percentage or concentration of NH_3 and NH_4^+ can be computed if pH and temperature are known. Some calculated percentages of un-ionized ammonia in an aqueous ammonia solution of zero salinity against varying pH value and temperature is presented in the following tabulation:

(1)

Percent Un-ionized Ammonia (NH_3) in Aqueous Ammonia Solutions

Temperature Degrees Centigrade	pH					
	6.5	7.0	7.5	8.0	8.5	9.0
	%	%	%	%	%	%
5	0.040	0.12	0.39	1.2	3.8	11.
10	0.059	0.19	0.59	1.8	5.6	16.
15	0.087	0.27	0.86	2.7	8.	21.
20	0.13	0.40	1.2	3.8	11.	28.
25	0.18	0.57	1.8	5.4	15.	36.
30	0.25	0.80	2.5	7.5	20.	45.

(1) From: Emerson, Russo, Lund & Thurston "Aqueous Ammonia Equilibrium Calculations, Effect of pH and Temperature," J. Fish. Res. Board Can. 32 (12) 2379-2383 (1975). (Exh. 1E, 8 - Bibliography Reference 24)

The Illinois State Water Survey Report ISWS-77-RI85, Roseboom and Richey, p30, concluded, after applying a factor of 1/10 to the 96-hour TL 50 observed in their study, that bluegill, largemouth bass and channel catfish would be protected in Illinois streams when NH_3 (un-ionized ammonia) does not exceed 0.04 mg/l.

Their tabulation of concentrations of total ammonia which will produce 0.04 mg/l of NH_3 at various pH and temperature values is as follows:

TEMP. (°C)	pH					
	6.5	7.0	7.5	8.0	8.5	9.0
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
5	127.4	36.0	11.4	3.60	1.18	0.40
10	76.3	24.1	7.66	2.45	0.80	0.28
15	52.08	16.5	5.24	1.69	0.56	0.20
20	35.7	11.3	3.60	1.17	0.40	0.15
25	25.0	7.95	2.55	0.83	0.29	0.12
30	17.62	5.60	1.80	0.60	0.22	0.10

From Roseboom & Richey - Table 11

In Exhibit 1C, the Agency presented data concerning water quality ammonia violations for samples exceeding 1.5 mg/l for years 1973 through 1976 and detailed reported fish kills caused by ammonia in 1976, none of which resulted from treatment plant discharges. Dr. David J. Schaeffer, Science Advisor to the Manager, Division of Water Pollution Control, IEPA, testified

concerning the significance of the number of stations exceeding 1.5 mg/l. He stated that the exhibit indicated that about 10 percent of the stations (about 55) exceed the 1.5 mg/l standard monthly; that the number of stations which violate the standard is small; that a small fraction of the total data collected shows water quality violations; and that the percentage of violation over the standard is relatively small (R. 163). Mr. Park testified that while these discharges may have localized impacts, their impact on water quality in general will be small (R. 61). Mr. Leonard C. Crawford, of Crawford, Murphy & Tilly, Inc., Consulting Engineers, who has practiced as a professional consulting engineer for about 35 years, gave testimony concerning the localized impact of the discharge of ammonia nitrogen (T. 47-49). The Agency stated that the experienced frequency of ammonia nitrogen water quality violations will be steadily decreased as the over 200 treatment plant projects currently under construction are completed and placed in operation (Exh. 1A, 13-14).

Exhibit 1-I is Chapter 3 (p46-62) excerpted from a report of May, 1976, entitled "A Critical Evaluation of Current Performance of Some Activated Sludge and Lagoon Systems in Illinois" by Bharat Mathur, P.E. and Carol Houston, both of the Division of Water Pollution Control, Illinois Environmental Protection Agency. Table 11 of Exhibit 1-I, is a summary of ammonia nitrogen in lagoon effluents in Illinois, as follows:

AMMONIA NITROGEN IN LAGOON EFFLUENTS*

	Average NH_3-N Concentration in mg/l	
Three Cell Waste Stabilization Ponds	2.3	
Three Cell Aerated Lagoons	2.1	
Three Cell Waste Stabilization Ponds Performance by Month		
January	6.3	(27)**
February	3.1	(28)
March	3.6	(21)
April	2.4	(29)
May	1.7	(33)
June	1.43	(21)
July	0.38	(24)
August	0.76	(18)
September	1.4	(29)
October	2.3	(36)
November	2.3	(24)
December	2.1	(26)

AMMONIA NITROGEN IN LAGOON EFFLUENTS* (continued)

	Average NH_3-N Concentration in mg/l
Three Cell Waste Stabilization Ponds	
Plants North of Highway 116	2.6 (14)
Plants Between 116 and US 50	1.4 (96)
Plants South of US 50	2.8 (216)

*(Exh. 1-I, 50)

**Values ( ) indicate number of samples.

Based upon this report, it can be concluded that existing three cell waste stabilization ponds and aerated lagoons should not violate a 1.5 mg/l limitation June through September. During other times of the year, the amount of flow in the receiving streams will control compliance with the 1.5 mg/l limitation October through May. The effect of discharges from three cell natural and aerated waste stabilization ponds on water quality during the winter months is expected to be minimal considering the data concerning the decreasing toxicity of ammonia as temperature falls (Exh. 1-I, 49-51; 1A, 10).

Exhibit 1-D presented by the Agency is a summary of information relative to existing regulations in several other states regarding ammonia nitrogen standards and practices; Mr. Park testified that of the six states surveyed, only Pennsylvania (1.5 mg/l summer, 4.5 mg/l winter) and Wisconsin (controlled discharge) had standards for intermittent streams (R. 130-133).

NO CHANGE IN WATER QUALITY STANDARD

The Agency has not proposed that the existing ammonia nitrogen water quality standard be changed at this time. Mr. Park testified (R. 9, 21-22, 35) that the Agency will propose an appropriate un-ionized ammonia water quality standard as soon as valid toxicity data for Illinois waters can be developed to support a revision to the current standard. The Illinois State Water Survey and the Illinois Natural History Survey are both doing bioassay work on ammonia toxicity to identify water quality needs specifically for aquatic species present in Illinois waters. The Agency, in conjunction with their work, is attempting to tailor water quality requirements more closely to the existing and anticipated uses of given water segments (R. 13-14).

SUPPORT FOR THE PROPOSED CHANGE

In the hearing of May 10, 1977, Mr. G. W. Henderson, Superintendent of the Galesburg Sanitary District, presented a statement prepared by the Board of Trustees and signed by their President requesting a change of regulations. Mr. Henderson testified that the ammonia levels in the effluent from their treatment works vary from above 1 mg/l in warm weather to as high as 5 or 6 during December, January and February when temperatures ranged between zero to 20 degrees below (R. 45). He further testified that since the effluent maintains the flow in the receiving stream, the effluent must meet the ammonia nitrogen water quality standard (R. 43) and that the cost of meeting the standard had been estimated at $4.75 million (R. 38).

The Consulting Engineers Council of Illinois, through the testimony of Mr. Riddell and Dr. Wilson and in a statement entered into the record as Exhibit 3, concurred the Agency exemption of small sources and require the minimum use of breakpoint chlorination but stated that the proposal fell short of adequacy in that it did not include an un-ionized ammonia water quality standard (Exh. 3, 4-5).

A letter of agreement with the proposed regulation, dated May 6, 1977, and signed by Bart T. Lynam, General Superintendent of the Metropolitan Sanitary District of Greater Chicago was placed into the record as Exhibit 6.

Mr. Allen Panek, Superintendent of the Water Supply and Reclamation Division of the City of Naperville, testified in support of the proposal and stated that they were achieving an effluent concentration of 1.5 mg/l during summer months but that the wintertime limitation of 4.0 mg/l might not be realistic based on their experience (R. 110-114).

Mr. L. K. Crawford, of Crawford, Murphy & Tilly, Inc., Springfield, testified in behalf of the proposed regulation and recommended in addition that the Board delete ammonia nitrogen concentrations requirements for discharges to intermittent streams or ditches until there was a showing that ammonia nitrogen reduction was necessary to protect the streams or aquatic life and that technology was available to safely provide the reduction necessary. Mr. Crawford expressed concern that by adhering to current requirements or even the proposed rule change that a number of "white elephants" could be constructed which are not required from an environmental standpoint (T. 44-65).

Mr. A. Paul Troemper, Executive Director of the Springfield Sanitary District, concurred in full with the conclusions presented by Mr. Crawford in a letter dated September 20, 1977, in which he stated that no distress situation had been noted in fish below

their Sugar Creek Plant even though the 1.5 mg/l standard had been exceeded during periods of extreme low flow. An earlier letter dated June 1, 1977, from Mr. Troemper included weekly readings of ammonia nitrogen from January, 1975, through May, 1977, taken in Sugar Creek downstream of the treatment plant noting that no adverse affect had been noted on the fish life in the stream. He further stated that in his opinion chlorine carryover in the effluent had adversely affected fish life.

Mr. John Treuthart, District Engineer of the DeKalb Sanitary District, submitted a letter dated May 23, 1977, requesting favorable consideration of the proposal. Mr. Treuthart stated that the rotating biological contactors being installed in their upgraded facilities would provide ammonia nitrogen removal to 1.5 mg/l except during the coldest months and that the effluent discharged during the winter would have no detrimental effect.

Letters in support of the proposed regulation were also received from the Illinois Association of Sanitary Districts on May 17, 1977, and the Southwestern Illinois Metropolitan and Regional Planning Commission on June 9, 1977.

There was no testimony or comment submitted in opposition to the proposed rule except the testimony noted above which suggested that the Agency proposal does not go far enough.

FINDINGS AND CONCLUSIONS

The Board has reviewed the record in this proceeding and finds that the procedural requirements of the statute and regulations regarding the adoption of regulations have been fulfilled.

The proposal was originally submitted as a variance petition by the Agency which the Board construed as a regulatory proposal believing that such a variance petition by the Agency was beyond the contemplation of the Act. The Board finds merit in the request for an interim exception for the existing small sources, not otherwise requiring upgrading, pending the gathering of appropriate bioassay data to either verify the existing standard established by Rule 203(f) or to establish a more appropriate one. It does not appear from the record that existing water quality will be degraded during the period of the proposed exception to Rule 402 because they will be required by permit to provide ammonia reduction consistent with their existing works and process. It appears most likely that water quality will show constant improvement as new and upgraded treatment plants begin operation during the period and the effluent limitations proposed by 402.1(b), where none now exist, are implemented. The Board is persuaded that the use of breakpoint chlorination as a backup to

biological processes may well cause a more significant problem in the aquatic environment than the remaining fraction of the ammonia nitrogen removed by the breakpoint chlorination, at least to the extent that wide-spread implementation of break-point chlorination be deferred pending a thorough investigation into the necessity for the use of such a process.

The language of the Agency proposal has been slightly modified in an attempt to insure clarity. Rule 402.1(a) excepts the small sources if they:

(1) have an ammonia nitrogen influent loading of less than 60 pounds per day; and

(2) were in existence on April 1, 1977; and

(3) do not require upgrading to meet any other requirement of Chapter III.

If a source does not meet each one of these three criteria, it must comply with the requirement of 402.1(b) and (c) which provide that such source meet an effluent discharge limitation of 4.0 mg/l November through March beginning March 31, 1979, or as otherwise required by permit condition or order of the Board in a variance or enforcement proceeding. The compliance date is established to allow for facilities now planned or under construction to be completed and to achieve compliance in accordance with the realities of the biological processes employed. The provision for other dates will allow for earlier dates of compliance because facilities are already under construction or operational or because unusual circumstance, such as grant program delays, dictate later compliance. The termination date for Rule 402.1 is established as July 1, 1982, which the Board believes is the practical minimum in which to collect the detailed data to support any necessary regulatory change and to allow for proper hearing and consideration by the Board.

PROPOSED FINAL ORDER

Proposed Rule 402.1 Exceptions to Rule 402 (Ammonia Nitrogen)

a) Rule 402 shall not apply to that portion of Rule 203(f) pertaining to ammonia nitrogen for any effluent from a source in existence on April 1, 1977, having an untreated ammonia influent loading not exceeding 60 pounds per day and not otherwise needing upgrading to meet the requirements of this Chapter.

b) Rule 402 shall not apply to that portion of Rule 203(f) pertaining to ammonia nitrogen for any source during the months of November through March; except that during the months of November through March no source, not exempt under 402.1(a), shall discharge an effluent containing a concentration of ammonia nitrogen greater than 4.0 mg/l if the discharge, alone or in combination with other discharges, causes or contributes to a violation of that portion of Rule 203(f) pertaining to ammonia nitrogen.

c) Compliance with the provisions of Rule 402.1(b) shall be achieved by March 31, 1979, or such other date as required by NPDES permit, or as ordered by the Board under Title VIII or Title IX of the Environmental Protection Act.

d) After July 1, 1982, the exemptions provided in this Rule 402.1 shall terminate.

I, Christan L. Moffett, Clerk of the Illinois Pollution Control Board, hereby certify the above Proposed Final Opinion was approved for publication and public comment on the 30th day of March, 1978 by a vote of 5-0.

Christan L. Moffett

Christan L. Moffett, Clerk
Illinois Pollution Control Board