ILLINOIS POLLUTION CONTROL BOARD
August 18, 1982

In the Matter of: AMENDMENTS TO CHAPTER 3: WATER POLLUTION (Effluent Disinfection)	)))))	R77-12 (Docket D)

Proposed Rule. Second Notice.

OPINION OF THE BOARD (by D. Anderson):

On May 10, 1977 the Illinois Environmental Protection Agency (Agency) proposed certain amendments to Chapter 3: Water Pollution, since codified as 35 Ill. Adm. Code, Subtitle C, Chapter I, Parts 301 through 312. The Agency proposal was published in Environmental Register #148, June 9, 1977. On July 5, 1977 the Hearing Officer created Docket D, into which was placed the portion of the proposal dealing with the effluent and water quality standards for fecal coliform. The Agency made minor amendments to its proposal on the record at a hearing (9:188). The following is a summary of the Agency Proposal:

Rule	Codified Section	Summary of Proposal
203(g)	302.209	Delete general use water quality standard for fecal coliform
*205(g)	302.406	Delete secondary contact water quality standard for fecal coliform
405	304.121	Condition the fecal coliform effluent standard of 400 per 100 ml so it would be applicable only if the discharge is within 20 miles upstream of a bathing beach (during swimming season) or a public water or food processing water supply, or so as to protect another state's water quality standards.

*Rule 205(g) became Rule 205(d) prior to codification (3 Ill. Reg. 20, page 95, May 18, 1979).

HEARINGS

Ten public hearings, all followed by public comment, have been held in three groups. First, five merit hearings were held on the Agency proposal in 1977 and 1978. Next, in 1981, the Board received from the Department of Energy and Natural Resources the economic impact study as required by the Environmental Protection Act (Act). Three economic impact hearings were then held in mid-1981. Then, on October 8, 1981, the Board sent a proposed rule to first notice to be published in the Illinois Register pursuant to the Administrative Procedure Act (APA) (43 PCB 479, 5 Ill. Reg. 11,679, November 6, 1981). This was followed by two more hearings in which both the Agency and Board proposals were addressed. The Board proposal differed from the Agency proposal in that the effluent standard for fecal coliform also would be applicable within 20 miles upstream of any lake or within 20 miles of the main stem of the Illinois River downstream of Morris. The Board also proposed to change the definition of "primary contact".

The Board's action today eliminates the proposed language added by the Board's October 8th proposal, thus reinstating the Agency proposal, and sends this rule to the Joint Committee on Administrative Rules as second notice pursuant to the APA.

The following is a listing of the hearings:

Volume	Pages	Date	Location
1	1-84	October 3, 1977	Springfield
2	86-165	October 5, 1977	Chicago
3	166-283	" " "	"
4	286-345	January 26, 1978	Chicago
5	2-5	January 27, 1978	Chicago
6	347-529	March 7, 1978	Chicago
7	2-74	June 29, 1981	Chicago
8	76-106	June 30, 1981	Chicago
9	108-203	July 17, 1981	Bloomington
10	204-396	February 9, 1982	Chicago
11	397-661	February 10, 1982	Chicago

Because the transcripts are not numbered sequentially, it is necessary to indicate volume number. Thus, "9:110" will mean page 110 in Volume 9.

Some commenters have suggested that the record is inadequate and that the Board should hold additional hearings (D-51, PC 103). As already stated, the Board conducted numerous hearings, generating over 1200 pages of transcript, and received extensive public comment over a period of five years, following three separate public notices. The Department of Energy and Natural Resources submitted a full economic impact study prior to the second round of hearings. Then, following the formal first notice and extended public comment period, the Board scheduled two additional hearings. During all of these hearings the opponents had a full opportunity for presentation. This was followed by another time period for further public comment. It is difficult to believe that any further useful information can be added to this already voluminous record through further hearings.

EXHIBITS AND PUBLIC COMMENT

Sixty-four exhibits were received during the course of this proceeding. The following exhibits provide a representative discussion of many of the issues involved:

Exhibit Number	Description
D-1	Agency Proposal
D-8	Comptroller General's Report to the Congress-- Unnecessary and Harmful Levels of Domestic Sewage Chlorination Should be Stopped (CED-77-108, August 30, 1977).
D-27	Economic Impact Study "The Economic Analysis of Health Risks and the Environmental Assessment of Revised Fecal Coliform Effluent and Water Quality Standards", ENR Doc. No. 81/15
D-30	Illinois Association of Sanitary Districts
D-51	Technical Arguments Against the Adoption of Changes in the Illinois Wastewater Fecal Coliform Standards by Charles N. Haas, Ph.D., sponsored by K. A. Steel, Inc.
D-10,50	Metropolitan Sanitary District of Greater Chicago

One hundred and five public comments were filed in Docket D. However, closer inspection revealed that twelve of these related to other dockets only. The following are representative:

PC 6, 11, 32, 40, 51, 52, 105	Metropolitan Sanitary District of Greater Chicago (MSD)

PC 13, 21, 22, 27 30, 37, 39, 65, 67, 102, 104	Illinois Environmental Protection Agency
PC 35, 38, 42, 57	K. A. Steel Chemicals, Inc. (K. A.)
PC 44	Greater Peoria Sanitary District
PC 68, 100	American Waterworks Service Company, Inc.
PC 80	Peoria County Board
PC 83	Mayor of Peoria
PC 103	Illinois Attorney General

HISTORY OF DISINFECTION

Widespread municipal wastewater disinfection dates only to the 1960's, with chlorination then and now being the commonly used method in the disinfection process (6:464). In 1972, the Board adopted year round fecal coliform effluent and water quality standards of 400 counts/100 ml and 200 counts/100 ml, respectively (R70-8, R71-14, 3 PCB 755, 4 PCB 3, March 7, 1972 and April 14, 1972). A similar effluent standard was adopted by USEPA in 1973. However, this was deleted by the USEPA on July 26, 1976 after fish kills and research indicating harmful aspects. The Agency proposal followed soon thereafter (1:8; 4:291; 6:466, 479, 504; D-5, D-8, D-27, p. 15).

Other states take a variety of approaches in their water quality and disinfection strategies (D-34, 35). Although 24 states do not have a statewide wastewater effluent standard, most appear to require disinfection to some degree. A few do not permit chlorination in fish hatchery areas. Disinfection generally is either not required or actively discouraged in the European countries studied (PC 103, 105; D-27, p. 96; D-24).

RATIONALE FOR DISINFECTION

The disinfection process was initiated as an attempt to kill any disease-causing organisms which may remain in the treated secondary effluent from a sewage treatment plant before discharge to surface waters.

Actual presence of any disease-causing organisms is not directly monitored because such organisms are difficult to detect. Instead, the Board's standards set effluent discharge limits for indicator bacteria, fecal coliform, which are commonly present in the intestines of warm blooded animals--humans, livestock, pets, rabbits, birds, etc.--whether or not there are disease-causing organisms present.

The disinfection process is intended primarily to reduce the waterborne disease potential for those downstream who may ingest the surface waters. Another reason is the possible reduction in disease-causing organisms near any surface water intakes of water supply facilities that treat and distribute drinking water. Other reasons given include odor control and protection of oxygen levels in the receiving stream.

Odor control is doubtful (11:454, D-52). Protection of dissolved[1] oxygen (DO) levels may be more significant environmentally. Some contend that chlorination may suppress the rate of oxidation of ammonia nitrogen ("nitrification") in the stream (PC 52). This would help maintain DO levels downstream,. However, it appears that DO levels are in fact higher in the absence of chlorination (D-52). Chlorination also interferes with the natural removal of a pollutant, ammonia (PC 9, 47, 52). This is further discussed below. The control of odors and protection of DO levels is better accomplished through direct enforcement of existing rules on odor, DO, oxygen demand and ammonia. Repeal of the disinfection requirement would not prohibit use of chlorine to control these parameters, although this would require a permit condition.

COMPLIANCE WITH CURRENT STANDARDS

About 90% of the discharges in the State practice disinfection, yet the waters of the State are regularly in excess of the water quality standard. About half of all samples taken from waters of the State are in excess of 200 counts/100 ml. A level of 3500 counts/100 ml is exceeded 10% of the time (7:9, 24; 10:358).

The widespread violation of the water quality standard in the presence of nearly universal disinfection of point source discharges is indicative of the failure of this control strategy. The water quality violations are attributed to non-point sources, natural and manmade: wild animals, livestock grazing, agricultural and urban storm runoff and septic tanks contribute fecal coliform (6:375, 429, 486; 10:282, 323; 11:478, 487). Disinfection of these sources would be prohibitively expensive (6:497; 10:364; 11:440).

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[1] For purposes of this opinion, "public health hazard" and similar expressions will refer to immediate health risks, such as the danger of waterborne disease or a chlorine gas leak. On the other hand, "environmental impact" will include impacts on natural resources and wildlife and long range threats to human health, but exclude "public health hazards" as defined above, even though the term usually includes such hazards. The Board will weigh "public health hazards" against "environmental impacts," so defined. This terminology is more concise for the purposes at hand.

METHODS OF DISINFECTION

In Illinois, disinfection is accomplished by chlorination. There are, however, several other methods that have been proposed or have had limited operational use (D-7, D-18, D-27, p. 66):

1. Chlorine dioxide
2. Ultraviolet light (UV)
3. Ozone
4. Bromine chloride

These have a number of advantages and disadvantages when compared with chlorination (6:384, 481; 7:26; D-27, p. 71). Chlorine dioxide must be generated on site and poses a hazard of fire and explosion (11:556; D-56). UV requires an effluent with low suspended solids and organic content (10:291; 11:416, 608). Ozone must be generated on site with complex equipment (10:291; 11:462, 608). Bromine chloride seems to be safe and easy to install, but is expensive and poses unanswered questions about the advisability of introducing large amounts of bromine into waters of the State (7:26).

The Board does not have detailed cost estimates of conversion of existing facilities to these methods of disinfection. Bromine chloride could be introduced with minimal additional capital investment, although it has problems as noted above. Chlorine dioxide, UV and ozone could require installation of new equipment and redesign of existing plants.

The proposal before the Board is to discontinue requiring the use of the fecal coliform standards under certain circumstances. The record is understandably deficient on technical evidence to support an action requiring a shift to those other methods of disinfection. However, it seems clear that the cost of ozone, UV or chlorine dioxide, if required statewide, would be in the tens or hundreds of millions of dollars and that, in the absence of a regulation requiring a shift, dischargers would continue to disinfect with chlorine. The possibility that the adverse environmental effects discussed below could be reduced through improved disinfection methods is not relevant in the absence of a proposal requiring a shift to these methods. Moreover, in light of the minimal public health benefits of disinfection, which are discussed below, it is doubtful if any regulation requiring a statewide shift to new methods of disinfection could be adopted.

Chlorination may be carried out either with direct introduction of chlorine gas, or through addition of sodium hypochlorite. The latter is a solid which must be dissolved in water, but is safer to store. It requires more equipment and attention from personnel, and is generally used only at very large facilities (7:50; 11:611).

In either method of chlorination, the principal active species appears to be hypochlorous acid (HOCl). This is a strong oxidizing agent which, if it comes in direct contact with microorganisms, reacts in an incompletely understood manner which results in their death or inactivation. pH and temperature affect the process (D-27, p. 54; PC 105).

Ammonia and any organic matter interfere with chlorine's disinfecting action. Ammonia, and any amines present, form chloramines, primarily monochloramines (R_2NCl, where R may be hydrogen or other radicals)(9:151; 11:617; D-27, p. 54). Active sites on carbon atoms in organic molecules are also susceptible to chlorination, a common product being chloroform ($CHCl_3$)(11:602, 605). These processes "compete" with the microorganisms present for the available chlorine: as the concentration of organic carbon and ammonia nitrogen in the wastewater increases, more chlorine must be added to accomplish a given level of disinfection (6:404). Another form of interference arises at high levels of total suspended solids (TSS): bacteria and viruses become entrapped in large particles and are physically protected from disinfection (6:384, 404; 9:130; PC 105).

The disinfection process is frequently monitored through chemical tests for total residual chlorine and free available chlorine. High levels of residual or available chlorine are taken to mean low levels of fecal coliform. Available chlorine measures chlorine present as free chlorine, hypochlorous acid or hypochlorite ion. Residual chlorine also includes chlorine present as chloramines. Success of disinfection of public water supplies is measured by available chlorine in the supply system after treatment.[2] Available chlorine is not a useful measure in wastewater disinfection: the available chlorine is usually converted to chloramines before it can be dispersed in the wastewater. Thus the success of wastewater chlorination is monitored as residual chlorine in the field (6:513; 9:149).[3]

Chloramines (residual chlorine) appear to have some disinfecting capability, either through direct action on microorganisms or through conversion back to available chlorine. The disinfecting power of chlorine is 25 to 100 times as great as monochloramine (D-27, p. 54; 6:384).

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[2] This terminology will be used in this Opinion; however, it is not universally used in the record: "available chlorine" is often referred to as "residual chlorine", especially in reference to water supplies.

[3] Board regulations do not require maintenance of any level of residual chlorine. However, because the fecal coliform culture method takes time to get results, residual chlorine monitoring is a practical way of monitoring and controlling chlorination equipment.

Effluent chlorination is effected in a "contact chlorinator". This provides a chlorine feed and mixing of the chlorine with wastewater. The usual "contact time" is 15 to 30 minutes. Many feel that "disinfection" is a misnomer when describing the process, in part because the contact time can be insufficient. In public water supply chlorination available chlorine continues to disinfect for hours or days in the distribution system after treatment; however, wastewater is discharged after less than an hour of exposure to chlorine. The residual chlorine, a weaker disinfectant to start with, is then diluted in the stream. It has been suggested that the chlorination process could be improved through increased mixing and longer contact time, perhaps with lower levels of chlorine feed (6:407; 9:150; 10:290; D-28, 35).

Part of the environmental objection to chlorination stems from the discharge of free chlorine and chloramines. These may be reduced by "dechlorination". This involves addition of sulfur dioxide to the waste stream following chlorination. In some cases it is necessary to reaerate to strip excess sulfur dioxide and restore DO levels prior to discharge (10:290; 11:420, 463, 503; D-27, p. 66). Dechlorination at a minimum involves addition of sulfur dioxide feed units to treatment plants, and may require additional investment in reaeration facilities. Sulfur dioxide is a hazardous material which would expose the public to additional risk (PC 104).

Dechlorination does not satisfy all of the environmental objections to chlorination: it has no effect on chlorinated organics. In addition, commenters have questioned its efficacy in reducing monochloramines (PC 104, 105). The apparent reduction in residual chlorine may be due to interference with analytical methods by sulfite (PC 105).

PATHOGENS

Waterborne disease comes primarily from contaminated drinking water, with diarrhea and intestinal upset being the most common symptoms. Some of the same organisms spread disease through contaminated food and person to person contact. Disease-causing organisms in raw sewage prior to treatment come primarily from human fecal matter (D-27, p. 38). These include viruses, bacteria and the cysts, larvea and eggs of intestinal parasites. Bacteria alone make up as much as one-third of fecal material. Most of these bacteria are normal intestinal flora in warm blooded animals and do not cause disease. Among the bacteria found in raw sewage which can cause disease are the following:

Organism	Disease
Salmonella	Salmonellosis Typhoid
Shigella	Shigellosis (dysentary)
Vibrio cholerea	Cholera
Enteropathogenic E. coli	Cholera-like symptoms

Among the viruses are echovirus, coxsackie virus, adenovirus and hepatitis A. These primarily cause gastrointestinal upset as well as mycocarditis, aseptic meningitis, and respiratory involvement (D-27, p. 44). Inactive polio-virus is also found, apparently shed by persons who have received live polio vaccine (11:566, 570).

These organisms differ in abundance, infectious dose, severity of resulting disease, and susceptibility to chlorination. Hepatitis and salmonellosis can result in severe disease, while shigellosis is more common (11:536, 586).

IS FECAL COLIFORM AN APPROPRIATE STANDARD?

Coliform bacteria counts are done through a laboratory procedure involving dilutions, innoculation into a culture medium, incubation and a count of resulting colonies. Limitations on the test include the possibility that some bacteria will fail to form visible colonies, or that clumps of bacteria will form a single colony (6:431).

The effluent and water quality standards of Subtitle C are based on fecal coliform; the public water supply standards of Chapter 6 are based in part on total coliform. These are determined by slightly different testing methods. Fecal coliform is more indicative of waste from warm blooded animals; total coliform is a broader measure and may be found on soils and vegetation (1:10; 2:154; 6:368, 373). A general rule of thumb is that total coliform is about five to ten times fecal coliform (1:10; 10:263, 298); however, Rule 307(C) of Chapter 6: Public Water Supplies uses a ten to one ratio.

The fecal coliform standards are difficult to administer in part because any bacterial testing method is subject to errors, and in part because the number of fecal coliform bacteria in a given effluent discharge can vary over as much as six orders of magnitude. However, there are more fundamental problems with the fecal coliform standards.

The purpose of a water quality standard is generally to fix a level necessary to protect various stream uses (2:154).

Effluent standards on the other hand fix a level considered to be good treatment efficiency. The fecal coliform standard does not correlate well with protection of stream uses, and is not indicative of the efficiency of the basic treatment processes.

Sewage treatment and disposal sometimes involve digestion by bacteria which are naturally present in sewage or are deliberately introduced into the treatment process. These bacteria mostly settle out as suspended matter and are removed as sludge; some no doubt are carried over and discharged as TSS. These bacteria are not thought to pose any threat to public health. Many fecal coliform bacteria and pathogens also settle out or are consumed during treatment (6:506).

The treatment processes are monitored through such parameters as oxygen demand and suspended solids. Fecal coliform is not a good indicator of the success of treatment in a basically well designed and operated plant (6:381, 505; 9:127). Although it may be a good measure of untreated fecal matter in water, it is not necessarily a good measure of the success of the treatment process in removing pathogenic constituents (2:117, 127; 6:368, 417, 448, 458; 11:414; PC 5, 6, 10, 15, 16, 17, 103, 104, 105).

The fecal coliform water quality standard is increasingly questioned as to its reliability in reflecting the presence of harmful, pathogenic constituents (D-36, 42). As summarized earlier, the tests for fecal coliform do not actually measure pathogenic bacteria; rather, they measure usually harmless "indicator" bacteria which are commonly found in fecal matter. The actual identification and analysis of pathogenic bacteria, and viruses, is more complicated, and would be prohibitively expensive if carried out on a routine basis. Indeed, pathogenic intestinal bacteria do not generally give a positive response to the conditions of the fecal coliform tests. Of the pathogens, only enteropathogenic E. coli is counted as fecal coliform. This is ordinarily about one percent of the E. coli present. There is thus a possibility that water with a high fecal coliform count is harmless and, conversely, that water with a low count could contain dangerous pathogens, especially viruses (2:154; 3:206; 6:364, 372, 411, 436, 448, 478, 496; 9:132; 10:228, 242; 11:412, 446; PC 105).

Commenters have mentioned correlations between fecal coliform and pathogens (PC 103; 6:368, 448). A careful reading indicates that these correlations relate to fecal matter and not to treated sewage effluent.

Other standards have been proposed, including a count of shigella and pathogenic viruses. However, these are not well-developed and are extremely expensive. Their use in other jurisdictions appears to be restricted to public water supplies (11:412, 485, 585, 590; D-13).

As will be discussed below, fecal coliform levels appear to increase, or "regrow", after discharge of chlorinated effluents. There is considerable doubt that bacterial pathogens are able to survive and multiply in the receiving stream as well as the indicator bacteria; viruses are unable to multiply [D-21(f)]. This regrowth phenomenon contributes to violations of the water quality standards, but is not linked to any increase in any public health hazard. It is instead probably an artifact of the choice of fecal coliform as an indicator of bacterial quality (1:13).

The fecal coliform water quality standards apply even in streams which are not impacted by point source discharges, and the standards are regularly violated in such streams (10:282; Ex. 27, p. 30). The elevated levels of fecal coliform may be indicative of untreated fecal matter from such sources as feed-lots. In such a situation the water quality standard is more meaningful and would be useful in enforcement, although the uncontrolled sources would usually also cause violation of other effluent and water quality standards, such as ammonia. However, in actual practice, in the absence of an effluent standard, continuation of the fecal coliform water quality standard would result only in continued chlorination by point sources, rather than enforcement against non-point sources.

EFFICACY OF CHLORINATION IN PREVENTING DISEASE

Chlorination is aimed primarily at bacteria and related microorganisms. It is not very effective against intestinal parasites (6:385; D-27, p. 50; PC 41). While there is considerable dispute as to its effectiveness with respect to viruses, it is generally thought to be far less effective than against bacteria (2:140; 9:129).

Viruses are assayed by inoculating a tissue culture. After incubation, "plaques" are counted, giving the number of "plaque forming units", or PFU. This is equal to the number of viruses if each virus forms one plaque, and if only viruses form plaques. Virus counting is very expensive and there appears to be substantial uncertainty as to the efficiency of the count (10:370, 11:480, 564, 576). K. A. contends that the procedures undercount (10:300; 11:546, 568), while MSD believes they overcount (11:577, 626; D-24).

Pathogens exhibit "decay", both before and after discharge. Processes resulting in decay include sedimentation and consumption by predatory organisms. Decay results in actual removal of pathogens from the water. Flow rate affects the time to reach a given distance; slow flow allows more decay. Dilution reduces the concentration without actually decreasing the total number. The parties are in fairly close agreement as to half lives and decay modeling (10:292, 310; 11:426, 615). Argument seems to center on starting numbers of organisms, appropriate conditions of flow and dilution, and the number required to cause disease.

There are undoubtedly viruses in raw sewage; however, there is dispute as to whether they are present in treated effluents. MSD presented evidence that viruses were not detectable in the unchlorinated effluent in seven plants located in three states. MSD's data is summarized as follows (7:54, 60; 11:549; D-18, 19, 24):

	PFU/liter	
	Range	Average
Raw Sewage	0 - 80	0.7
Primary Effluent	0 - 44	0.5
Final Effluent	0 - 0	0

On the other hand, K. A. Steel contends that these numbers are too small by a factor of 10 to 100 (11:550; D-51). However, K. A. Steel's estimates are based on mathematical modeling done many years ago (10:327; 11:541, 546; D-54). Another reference cited by K. A. refers to virus levels in primary effluent. Discharge after only primary treatment is generally illegal in Illinois (10:300).

As stated earlier, it is generally agreed that chlorination is less effective against viruses than bacteria. However, while MSD estimates that 1 to 10% are inactivated; K. A. estimates 85 to 99% (10:289, 330; 11:554, 559). MSD takes the position that, assuming viruses are in an effluent, chlorination is so ineffective as to not be worthwhile. This is attributed to the poor viricidal properties of residual, as opposed to available, chlorine. Inactivation of viruses may require unrealistically long contact times (11:490). MSD contends that even with K. A.'s population and kill rate model, chlorination is not worthwhile (11:562; PC 105).

K. A. Steel's model assumes that there is a no-threshold response for viral or bacterial infection: that there is a possibility of infection resulting in disease if a single pathogen is ingested (10:310; 11:427, 531, 563). MSD, on the other hand, cites evidence that various amounts of pathogens can be ingested without contracting disease because of the body's defense mechanisms. MSD points out that about 100,000 polio viruses are needed in vaccination to ensure infection and resulting immunity (10:333; 11:567, 643). Even though these viruses are attenuated, these large numbers, administered mainly to children without harm, challenges the view that few viruses can cause disease. Mere dilution offers protection against disease.

The economic impact study based its economic analysis on its conclusion that there would be no health risk increase for recreational water use, and that the effect on public water supply use was largely based on failure rates for public water supply disinfection (9:113, 127, 33). Based on the possibility of a supply chlorination failure under adverse flow conditions, the economic impact was based on a maximum exposure of 132 persons to every 50 to 100 years (7:19, 33; D-27, p. 119). The excess pathogens passing normal supply treatment would result in exposure of about six persons per year, with actual disease incidence much lower (7:17, 30, 54; D-27, p. 117).

K. A. predicts much higher disease rates. It estimates 1200 to 10,000 additional cases of gastroenteritis and shigellosis transmitted by recreational exposure (10:286, 345, 347). However, as noted above, this estimate is based on elevated estimates of the number of virus particles discharged. In addition, the estimate is based on extrapolation of Lake Michigan swimming data to downstate Illinois parks (11:450). The K. A. predictions are further based on the assumption that the following worst case conditions are uniformly present: average conditions of flow and dilution, rather than a reasonable distribution; winter temperatures which slow decay (10:373); and, all swimming in the State occurring exactly 20 miles downstream of an unchlorinated treatment plant discharge (10:349).

The K. A. analysis is best characterized as a worst case, "what if" study which might form the basis of a reasearch proposal. The economic impact study applied general principles to actual situations occurring in Illinois (10:327; 11:583: D-37). It is fundamentally more believable.

Apart from estimates based on mechanistic considerations, there is a body of statistical evidence gathered from experience with chlorination. There is no historical "before and after" evidence for a decrease in waterborne disease incidence since institution of universal chlorination requirement in Illinois in 1972 (4:294; 6:378, 465; 10:284, 296, 354; PC 6, 41). There is no evidence of a higher waterborne disease incidence in Europe where wastewater disinfection is seldom practiced (7:35, 42; D-27, p. 96). There has been no evidence introduced of different disease rates in other states, which have varying degrees of chlorination (9:131; 10:322). Although the fecal coliform water quality standard is commonly, and substantially, violated throughout the State, instances of waterborne disease outbreaks caused by treated sewage effluent are non-existent. Reported outbreaks mostly concern failures in public water supply systems or swimming pool disinfection (2:115, 134; 6:412, 444, 469, 501; 9:134; 10:331; 11:526). Chlorinated or not, "Effluent from a properly operated wastewater treatment plant has never been reported as the source of <u>any</u> disease outbreak through primary contact" (6:379, 412, 459, 501; 7:55; D-27, p. 88). Disease incidence from drinking water supplies drawn from surface waters has been unaffected by the advent of extensive chlorination of sewage treatment effluent (D-27, p. 120). The economic impact study was based on the conclusion, after review, that:

> "analysis of reported disease incidence at the state, national and international level did not demonstrate any beneficial effects of wastewater disinfection" (7:44; D-16, 22, 25; D-27, p. 111).

The Illinois Department of Public Health supports the Agency proposal, as do others (2:95; 6:357; D-2, 16, 22, 25). However, the proposal is opposed by several local health departments (PC 5, 77, 78, 81, 85, 96).

The effect of disinfection on disease is best summarized in the response of the Center for Disease Control of the United States Public Health Service to a question from the Agency (D-15):

> "...there is no evidence that there has been any reduction in waterborne disease in the last 5 to 10 years. Nor have I seen any evidence based on studies of human disease that disinfection of sewage produces measurable public health benefits related to reduction of disease.
>
> For a variety of reasons, it is indeed true that results of epidemiologic studies attempting to relate bacterial levels in swimming waters with levels of illness have been, at best, equivocal."

REGROWTH

As noted above, pathogens exhibit natural decay in the sewers and streams. A part of this is due to consumption by other life forms. A healthy stream abounds with amoebae and higher animals which eat bacteria. Chlorination destroys these creatures as well as bacteria (11:514). It is therefore not surprising that fecal coliform levels appear to rise with distance downstream from chlorinated sewage treatment plants: the surviving bacteria multiply in a stream devoid of predators. Although fecal coliform may be a poor indicator, there is a possibility that bacterial pathogens are also multiplying (10:323; 11:435, 504, 513, 615, 637).

K. A. and others suggest that regrowth could be controlled by limiting the concentrations of nutrients in the treatment plant and in the streams and controlling all non-point and point sources (D-51; 6:377, 404, 451, 475, 491; 10:284; 11:431, 514, 637). Nutrients include nitrogen, phosphorus and carbonaceous oxygen demand. Control of non-point source nutrient loading, involving similar steps to control of non-point source fecal coliform, is proceeding slowly with great difficulty and expense. The Agency points out that, even if fecal coliform and nutrients were reduced, there is little indication that disease potential in Illinois' waters will be reduced, in part because it is already below detection limits (PC 104). In any event, appropriate limitation of these nutrients from point sources has been a primary goal of sewage regulation. Elimination of the chlorination requirement may free limited grant money for further investment in treatment facilities to limit these nutrients (10:323; 11:439, 485).

ECONOMIC BENEFITS OF DISINFECTION

Chlorination results in increased employment in sewage treatment plants and in the chlorine manufacturing and distribution industry. Although one prime beneficiary, K. A. Steel, supplies MSD with several million dollars worth of sodium hypochlorite anually, most of its chlorine supply business is with drinking water supplies (10:319). The Board does not view these benefits as particularly relevant to its consideration of whether to continue to require wastewater disinfection: any environmental regulation could be justified on a cost basis if control costs were treated as economic benefits.

Another possible economic benefit is decreased public water supply disinfection costs resulting from effluent chlorination. K. A. Steel, the Peoria water company (American Waterworks Service Company, Inc.), and the American Water Works Association contended that chemical costs would increase. They argue that, although disinfection would be required within 20 miles upstream of a supply intake, coliform bacteria can survive for long distances downstream.

Public water supply treatment typically involves sediment removal by coagulation and filtration prior to the addition of chlorine and entry into the distribution and storage system. However, public water supplies typically have much lower levels of ammonia and organic material to absorb chlorine and interfere with maintenance of sufficient levels of available chlorine for disinfection (10:260, 266, 383, 385).

The Peoria water company presented data which it argued showed a decrease in total coliform count in the Illinois River at Peoria since 1975 and a decrease in chemical costs for pre-disinfection with potassium permanganate in 1973 and 1974 (10:254; D-45). The water company suggested that the decrease was brought about by upstream chlorination. However, it was pointed out that the counts for 1966, 1980 and 1981 did not differ significantly (PC 105). The Board, after reviewing the transcripts and Peoria exhibits, questions any attempts to interpret Peoria's data, especially considering the overlapping time frames, the reasons given for the cost saving decisions, the problems with selectively using the data, and the discussion of the five year State Water Survey study in the economic impact study (D-27, p.32). It was also suggested that the reduction in disinfection cost was caused instead by installation upstream of treatment plants designed to remove suspended solids, nitrogen and organic matter which interfere with disinfection by permanganate (10:258, 262).

Also, as noted earlier, chlorination appears to interfere with the river's natural ability to absorb bacteria and to oxidize the nutrient loading which interferes with water supply treatment. Thus, one could conclude that the water company will see further decreases in chemical costs with an end to disinfection.

It should be noted that the Greater Peoria Sanitary District supports the end to disinfection (9:168; PC 44). K. A. contends that the savings to treatment plants, which are discussed below, are merely costs passed on to drinking water supply plants. However, this assumes not only no 20 mile zone, but also that 100% of effluents are used by supplies. In fact, only a small percentage of water supplies have a sewer discharge upstream (10:389; D-27, p. 35). Furthermore, it generally takes much less chlorine to disinfect a supply to a given level because of the lower levels of interference (10:383). The Board therefore concludes that, even if there is a possibility that a small portion of the treatment plant savings will be offset by increased drinking water supply treatment costs, there will be a large net savings in aggregate costs to the consumers of water and sewer service.

AGRICULTURAL BENEFITS

Another benefit may be protection of livestock from waterborne disease. The economic impact study found no impact on agriculture (7:20; 9:139). K. A. Steel estimates substantial potential economic losses to livestock owners of as much as one-half percent per year, or 4.5 million dollars, although such an estimate was admittedly a guess (10:303; 11:456, 498, 501). However, there appears to be little risk, since studies have reported that cattle and hogs can consume raw municipal sewage for two years without showing signs of disease (D-48, 11:457, 501).

New livestock management facilities may not contain surface waters or a stream [Rule 102(b)(1) of Chapter 5, Section 501.402(a)]. Indeed the practice of grazing livestock in waterways can be a greater source of coliform, suspended solids, nitrogen and organic carbon loading in Illinois streams than sewage treatment plants, with or without chlorination. The transmission of disease to man from uncontrolled livestock waste may be a far greater problem (9:140).

LIMITATIONS ON THE PROPOSAL'S EFFECT

A well operated system captures the sewer flows and removes pathogens by digestion, sedimentation and separation. One concern expressed was stream contamination by combined sewer overflows. However, the proposal here does not really address combined sewer overflows.

The Board proposal in this proceeding addresses the treatment of sewer flows that reach, are treated at, and discharged from the treatment plant, not sewer overflows bypassing directly to the stream. This usually occurs during a rainfall when the combined sewers can no longer contain both the storm and sewer water. The strategy for addressing this problem is contained in Board Rule 602 [Section 306.103(c)]. This rule essentially requires that first flush flows comply with the effluent standards and then primary treatment and disinfection for at least ten times the dry weather flow (3:271; 10:235, 248, 357; 11:487; D-59). The Board notes that amendments to Rule 602 are being considered in R81-17.

The effect of this proposal on Lake Michigan was of concern (3:199). This proposal will not result in any changes in the treatment of the few effluents discharging into Lake Michigan. Also, there appears to be confusion over the MSD river reversal to the Lake during heavy storms to prevent flooding and that can result in beach closings. During these periods, the river also contains the untreated overflows from both the combined sewers of the municipalities and the MSD interceptors that go directly into the river, a treatment plant. The MSD's "TARP" plan is intended to alleviate this combined sewer overflow problem, whether or not reversals occur, and is not part of this proceeding. Furthermore, the Lake Michigan water quality standard of 20 counts per 100 ml is not affected by this proposal (7:23). This must be the edge of a mixing zone around the discharge point (Rule 401, Section 302.102). Compliance with this standard will require a greater level of disinfection than that required by the 400 count/ 100 ml effluent standard.

Opposition was also based on a supposed change in beach closing standards. Beach closing standards are not set by the Board; rather this is regulated by the Department of Public Health and local government (6:396). The continuation of effluent chlorination within 20 miles upstream of licensed bathing beaches is intended to aid Public Health authorities in maintaining adequate bacteriological quality. It should be noted that the Board's fecal coliform standard for Lake Michigan is far more restrictive than the beach closing standard of 500 counts per 100 ml.

Opposition was also based on a supposed change in monitoring requirements (6:399, 468; 11:478). The Board notes that the proposal does not change monitoring requirements: the existing rules do not require fecal coliform monitoring, and their repeal will not prohibit the Agency from imposing monitoring, by way of permit condition, in appropriate cases, as allowed by Section 39 of the Act and Sections 305.102 and 309.146. In practice the Board expects to see no changes in the Agency's stream monitoring network and a substantial reduction in the frequency of effluent monitoring. The Board would prefer increased monitoring of parameters which relate to treatment efficiency.

The substantial cost of effluent fecal coliform monitoring is an indirect benefit of the proposal which was not included in the economic impact study.

20 MILES

Commenters contend that the 20 mile distance was chosen arbitrarily (6:418). They contend that pathogen die-off depends on temperature, flow-rate, dilution, nutrient loading and other factors which are too specific to allow a state-wide distance to be set. Commenters suggested that the Board review the 1600-plus dischargers in the State to make site-specific rules on disinfection.

The 20 mile figure was the Agency's original proposal. It was arrived at independently by Department of Public Health officials. It was evaluated and found to have positive impacts by the economic impact study. It lies within the range of distances which may be impacted. It has been subjected to numerous hearings with no better distances suggested (9:116, 123, 138, 141).

A statute sets a similar distance as the limit for municipal public water supply statutory oversight authority (Ill. Rev. Stat. 1981, ch. 24, par. 11-125-2). This distance however is fixed from the municipal boundary and appears to be a straight line distance. The 20 stream miles distance above the intake is more closely related to pathogen decay and yet will maintain reasonable consistency with this statute (9:124, 141).

In addition to evaluating the Agency proposal, the economic impact study evaluated the alternative of eliminating disinfection altogether. The public health consequences of even this alternative were determined to be de minimus. The Board finds that requiring disinfection within 20 miles of a beach or intake is a conservative rule which will provide a margin of safety and which may minimize beach closings (9:124). Where the discharge is to a lake or a body of water with no established flow, the effluent standard will apply if the discharge is within a 20 mile radius of a beach or intake on the body of water.

The Attorney General, although not testifying at the hearings, submitted a lengthy post-hearing comment (PC 103). Along with K. A. and others, it suggested that the Board take treatment plant processes off-line on a case-by-case basis. Under the Act this would require a site-specific rulemaking for each of the roughly 1500 dischargers which would probably be allowed to cease chlorination. This would require a regulatory effort of unprecedented scope costing many millions of dollars between the various State agencies and dischargers involved. In the interim, tens of millions would be spent on unnecessary chlorination, and hundreds of miles of streams would be unnecessarily degraded.

The public health benefit of requiring all of these dischargers to disinfect is negligible; the benefit of requiring only a few to do so must be less. The maximum possible gain from the site-specific approach would be to find that each discharger had to continue chlorination. Even this would not be worth the money that the regulatory effort would cost.

The Board recognizes that there may be specific cases where dischargers within the 20 mile zone could safely discontinue chlorination, and cases outside where adverse effects may appear. These few cases can be efficiently handled through site-specific rulemaking.

Commenters have also suggested that the proposal does not provide adequate protection for waterskiing. However, the record does not indicate the locations or existence of separately designated, promoted or protected waterskiing areas in Illinois. It is impossible to write an enforceable rule in the absence of specific locations or a means of designation which can be referred to (9:112).

DIRECT COSTS OF CHLORINATION

Direct costs associated with chlorination include capital outlays, labor, chemicals and supplies. Future capital investment in chlorination facilities will be avoided by those plants no longer required to disinfect. Existing plants will be able to avoid the daily expenses associated with chlorination, and will not have to set aside funds for replacement of existing equipment. The following summarizes the current costs of chlorination, with the projected costs and net savings following adoption of the limited disinfection requirements (7:20; D-27, p. 155):

	Current	Required to Continue	Net Savings
Direct Costs	$6,990,000	$330,000	$6,660,000
Amortization	2,500,000	50,000	2,450,000
Total Cost	$9,490,000	$380,000	$9,110,000

K. A. attacked these figures on the basis that the labor and amortization costs were overstated (10:287, 359; 11:603). MSD and the Bloomington-Normal Sanitary District on the other hand believed that the economic impact study understated the costs of chlorination (7:53, 56; 9:156; 10:319; 11:600; PC 32). The Board accepts the economic impact study figures as a good estimate of the savings.

SAFETY HAZARDS OF CHLORINATION

For the reasons noted above, chlorination is usually accomplished through addition of chlorine gas. This is an extremely hazardous material. Gas leaks can easily occur; and, the gas can easily cause severe injury or death to workers or members of the public in the vicinity of the plant. The economic impact study, in determining the economic impact, estimated that chlorine incidents would occur in Illinois about once every two years as a result of wastewater chlorination (7:50; 9:158; 11:594, 613; D-27, p. 161). A commenter reported an incident in February, 1980, at the Spring Creek Plant in Springfield. Disaster was averted only by prompt action of the operator, who had a mask available and was able to shut off the chlorine feed after a leak developed in a corroded line (PC 26). Safety kits cost about $700 per plant and are not generally available at treatment plants or fire departments (9:159). This cost, and significant training costs, were not included in the economic impact study (9:164).

CHLORINE MANUFACTURE

Chlorination in Illinois involves the manufacture and transportation of 9,300 tons of chlorine annually. This is about 0.06% of the national market for chlorine (7:22). The public at large is exposed to risk as this material moves in the distribution system. The environment is necessarily damaged as a result of this economic activity. A chlorine manufacturer is the largest point source of mercury in Illinois [Rule 702(f), Section 304.202]. Federal regulations based on process rate allow the discharge of 1200 to 2400 grams of mercury from the manufacture of this quantity of chlorine (40 CFR 415.62). The environmental hazards of this were recognized by the Board in its Opinion in R76-21.

ENVIRONMENTAL EFFECTS OF CHLORINATED EFFLUENTS

Environmental impacts on aquatic life include both immediate toxicity from available and residual chlorine and long term toxic and carcinogenic impacts from exposure to chlorinated hydrocarbons. Other environmental effects, which have been discussed above, concern DO levels and depression of stream nitrification.

It has been shown that residual chlorine stunts the growth of fish, halts or reduces spawning, and is lethal at concentrations of less than 0.1 mg/l. Other aquatic life shows toxic effects at similar levels. USEPA recommends a maximum level of 0.002 mg/l for salmonoid fish and 0.01 for other freshwater organisms (7:30; D-27, p. 129). Wastewater discharges are far in excess of these levels (7:16, 39; 8:86). There appears to be no dispute as to the toxicity of effluent discharges containing residual chlorine (10:304; 11:472; D-4, 31, 32).

Fish avoid levels or residual chlorine as low as 0.01 mg/l (D-27, p. 130). K. A. has taken the position that aquatic life is not actually harmed by residual chlorine but simply moves to other regions (11:451, 588, 618). This ignores the fact that aquatic populations generally increase until some limiting factor characteristic of the stream is reached. These could include such things as habitat or food availability. If additional fish move in from another area, the population will die off until the level dictated by the limiting factor is again reached (10:328). Thus, although a given fish may be able to avoid a given stream reach, for each mile of stream receiving chlorinated sewage effluent, there is one less mile of aquatic habitat available in the state and proportional reduction in the state's total fish population.

The economic impact study estimated that, depending on flow conditions, 60 to 697 stream miles are impacted by chlorinated effluents, compared to a total of about 12,000 stream miles in Illinois (7:15, 29; D-27, p. 149). The estimated value of the lost angling days is from $2,000,000 to $4,400,000 per year (9:390; D-27, p. 166). There appears to be no harm to fish from fecal coliform at typical discharge levels; nor is there any danger in eating fish taken from such water (6:400, 405, 423, 470; 7:37).

The long term toxic effects of chlorination are not so easily measured. Wastewater chlorination contributes significant levels of chlorinated hydrocarbons, especially chloroform (6:392, 404; 9:129; D-27, p. 139). MSD estimates that its activities alone contribute 4,670 pounds of chloroform and 8700 pounds of chlorine compounds daily to waters of the State (10:325, 339, 388; 11:602).

Chlorinated hydrocarbons are absorbed into lower level organisms. There is some evidence of direct toxic effects in aquatic life. In addition, chlorinated organic compounds are stored in fat. Concentrations in fat increase in animals higher in the food chain (11:594; D-27, p. 138). Some of this chlorine winds up far from the stream and in people.

The economic impact study estimates that effluent chlorination results directly in an increase of 0.00125 mg/l chloroform in the public water supplies of 200,000 people in Illinois. This is expected to cause a slight increase in cancer incidence (7:18; 11:602; D-27, p. 141).

Chlorinated hydrocarbons are a generic hazardous waste listed for toxicity (F001, F002, Section 721.131); the chlorinated hydrocarbons in wastewater which are listed in the economic impact study are listed hazardous wastes [Section 721.133(f)]. Considering this, the real question should be whether the Board should allow the deliberate introduction of these chemicals into the environment rather than whether it should require it (6:461).

As has been discussed above, chlorination may have other effects on parameters measuring stream quality, particularly ammonia and DO levels. Ammonia which is discharged in the form of chloramines may not be fully counted as ammonia nitrogen to determine compliance with the effluent and water quality standards. To the extent this is true, it is an artifact of the analytical technique producing the appearance of compliance without real environmental benefit since the chloramines are more toxic than ammonia and are eventually converted back to ammonia in the stream (10:236). Any use of chlorine to lower discharge ammonia levels cannot be condoned.

There is a dispute as to the effect on nitrification and DO levels. Chlorine is an oxidizing agent which, when reacting with organic matter, satisfies a portion of its ultimate oxygen demand. However, there is no evidence as to any direct effect of this partial oxidation on the rate and amount of biochemical oxidation in the stream. The impacts which are discussed concern the repression of nitrogenous oxygen demand while the nitrogen is tied up in chloramines, and while bacteria responsible for oxidation ("nitrification") are absent from the stream because of elevated residual chlorine levels. Some contend that the depression of nitrification should help to maintain DO levels in the stream. However, actual studies indicate the contrary result (D-52). Moreover, if DO levels are indeed improved, it is at the expense of the aquatic life in the stream which would benefit. Furthermore, the natural system for eliminating ammonia from the stream has been suppressed; ammonia is toxic to aquatic life. As noted above, protection of DO levels is left to the water quality standards for DO. Any discharger who wishes to chlorinate as a strategy for protecting DO levels may apply to the Agency for a permit (10:236, 387).

COMPARISONS BETWEEN WASTEWATER EFFLUENT AND DRINKING WATER SUPPLY CHLORINATION

The Board regulates both wastewater discharges to the stream and public water supplies to the tap. The Board recently rejected a proposal to allow small public water supplies to suspend chlorination (R78-8; October 30, December 4, 1980, 39 PCB 653, 40 PCB 89). The legislature, however, has allowed this under certain limited conditions for water supplies drawing from uncontaminated wells. The Board is in the process of modifying Chapter 6 in response (R81-28, Proposed Rule, Second Notice, Order of July 1, 1982). The Board's positions in favor of continued water supply chlorination, but against widespread wastewater effluent chlorination, although at first sight inconsistent, are fully compatible and stem from similar considerations.

Two different processes, delivering water to different places, are involved.

Drinking water, whether drawn from a surface water or a well, must be at a high level of purity. Smaller amounts of chlorine than are needed with wastewater are added before entering the distribution lines, where it remains in an enclosed system for considerable periods of time protecting against harmful bacteria, even those that may be present in the distribution system (7:33). In fact, the loss of available chlorine can itself indicate that there is a contamination problem in the system which must be corrected. The process, developed over the last half century, has been a proven lifesaver which does not harm the environment.

Sewage water, leaving homes and factories, and going to a treatment plant, no matter how highly treated, is discharged and diluted in a waterway, where chlorination provides little protection for people and harms the environment. Indeed, effluent chlorination produces more chlorinated organics than water supply chlorination, because of higher levels of interference. These compounds can persist in the stream up to the supply intake. Their removal may require aeration and activated charcoal treatment by the water supply system, without really reducing the amount of chlorine needed for water supply treatment.

MODIFICATION OF THE FIRST NOTICE ORDER

The Illinois Register proposal was the Agency's proposal with certain additional limitations. Chlorination would be required within 20 miles upstream of a public beach or supply intake. In addition, chlorination would be required within 20 miles of the main stem of the Illinois River downstream of Morris and within 20 miles of any lake. The comments received generally either favored the Agency's original proposal or oppose any change in existing requirements; there was little support for the Board's position on first notice.

There is considerable uncertainty as to what constitutes a "lake". It is unreasonable to require chlorination in the absence of any recreational use. The Board has therefore dropped this aspect of its proposal (PC 63, 65, 91; 10:222).

The requirement of chlorination within 20 miles of the main stem of the Illinois River suffers from a similar problem. Disinfection will therefore be required only upstream of water supply intakes and public bathing beaches (PC 44, 55, 63, 65; 9:113; 10:222).

Recreational use of water is largely restricted to the swimming season. The proposal will be modified to require disinfection only during May through September months where the discharge is upstream of a bathing beach. The Agency intends to write annual phase-in conditions into permits to avoid fish kills from sudden slugs of chlorine when disinfection commences in the springtime (6:388, 454, 483; 8:99; PC 65). Likewise, the Agency will review existing permits to determine whether the facility must continue chlorinating before modifying permits to delete fecal coliform limitations.

The Agency's original proposal included modifications in the definition of "primary contact", although there was confusion as to whether this was included in Docket D (1:29; 3:278). The proposed changes appear to be cosmetic only, correcting a misreading which is not very likely.

The definition of "primary contact" is used only in the preamble to the general use standards (Rule 203, Section 302.202) and, by way of contrast with the definition of "secondary contact", in stating the purpose of the secondary contact standards (Rule 302, Section 302.402). At the time R77-12 was proposed, there was a question as to whether a discharger could demonstrate that its receiving stream met the definition of "secondary contact" water, and thereby avoid the more restrictive general use standards. Had the Board allowed this, the wording of the definitions would have become a matter of great importance. However, the Board held that waters could be added to the list of secondary contact waters only by rulemaking [Olin Corp. v.PCB, 54 Ill. App. 3rd 480, 370 N.E. 2d 3 (Fifth District, 1977); R76-1, 32 PCB 377, 595, 33 PCB 423, 479, January 4, February 15, April 26, May 10, 1979; Rule 302, Section 303.102; 3 Ill. Reg. 20, page 95]. After this holding, the definitions served only to state the purposes of the designations. If necessary, the Board will consider modification of the definition in connection with a proposal to modify the listings of secondary contact waters.

SUMMARY

If disinfection were first proposed for adoption today, it is quite clear that the record would not support its widespread use. Now, however, available evidence of harmful effects and limited, at best, health benefits has greatly increased.

Even if alternatives may arguably avoid some of the adverse effects of chlorination, without substituting new adverse effects, the evidence of any benefits from widespread disinfection is too weak to support a regulation requiring a shift from chlorination practices.

The Board recognizes that there is always uncertainty in measuring the public health and environmental risks. However, the evidence before the Board indicates that the public health and safety considerations for and against chlorination balance out. The environmental damage caused by chlorination tips the scales, even without consideration of economic impacts, which significantly favor selective disinfection.

The Board will therefore modify its disinfection requirement consistent with the Agency's proposal. This Opinion supports the Board's Order of this date. The Clerk is directed to prepare a Second Notice and transmit it to the Joint Committee on Administrative Rules.

Jacob D. Dumelle dissented.

I, Christan L. Moffett, Clerk of the Illinois Pollution Control Board, hereby certify that the above Opinion was adopted on the 18th day of August, 1982 by a vote of 4-1.

Christan L. Moffett, Clerk
Illinois Pollution Control Board