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UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF THE
REGIONAL ADMINISTRATOR
REGION 5
230 S. DEARBORN STREET
CHICAGO, ILLINOIS 60604

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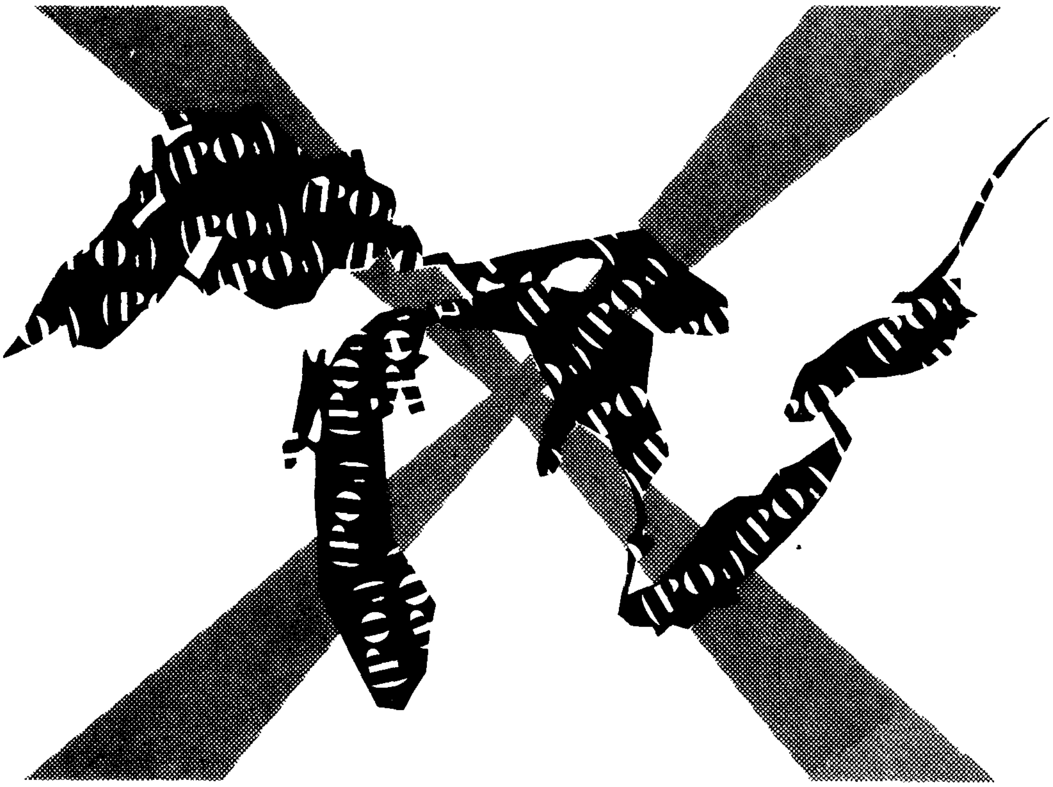
JUNE 1977

DETERGENT PHOSPHATE BAN

POSITION PAPER PREPARED BY THE REGION V PHOSPHORUS COMMITTEE



CORRECTION

Paragraph 5. on page 55 is misplaced, it should be inserted on page 56 right above TABLE A-2.

DETERGENT PHOSPHATE BAN

U.S. EPA, Region V, Position Paper Prepared by the
Region V Phosphorus Committee

George R. Alexander, Jr., Regional Administrator

Donald A. Wallgren, Committee Chairman

JUNE 1977

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INTRODUCTION

Region V of the U.S. Environmental Protection Agency now advocates that States in the Great Lakes Basin that have not already done so, give urgent consideration to the adoption of a ban on phosphorus in detergents.

This position is a departure from the EPA policy on phosphorus control from 1971 to the present. The policy was to rely on chemical treatment to reduce phosphorus levels in municipal sewage and industrial wastes discharged into waterways. Because this policy has failed to achieve the water quality goal of sufficiently decreasing and stabilizing rates of eutrophication in both inland lakes and the Great Lakes, not only Region V of EPA, but State governments and other regional and international agencies have recently been reconsidering the need and means of reducing phosphorus loadings. No other single factor is so important for the future water quality of the Great Lakes Region.

Through the 1960s both scientists and the general public became increasingly concerned about eutrophication in many waterways, especially lakes. The evidence of rapid eutrophication was the heavy growths of algae that appeared in most small lakes, in the western basin of Lake Erie, and in harbors and inshore waters of Lakes Michigan and Ontario. There were more and more frequent algae "blooms" that made water murky and smelly, piled slimy masses of decaying vegetation on beaches, and even caused massive fish kills due to oxygen depletion as the water plants decomposed.

While the public protested the immediate and unpleasant consequences of the acceleration of eutrophication that interfered with recreation and drinking water supplies, the scientists were most concerned about the impact on future water quality. They warned that fundamental, probably irreversible, changes in the natural biological systems were being caused by man's contributions to the nutrient levels in fresh water lakes.

Though there was no doubt that the rising levels of nutrients essential for algae growth were due to concentrations of man-made wastes, limnologists still debated for a time which nutrient was the limiting factor whose control could prevent the overloading of the natural ability of the lakes to renew and maintain themselves. By 1971, phosphorus was established as the limiting nutrient for all of the Great Lakes and most of the inland lakes of the region. It was clear, therefore, that decreasing and stabilizing rates of eutrophication depended on limiting phosphorus loadings to the waterways.

Although it is recognized that land runoff is a source of phosphorus from both chemical fertilizers and natural organic matter, attention centered on the fact that phosphorus loading from point sources had greatly increased with the use of phosphate detergents for both industrial and domestic purposes. The debate about how to keep phosphorus out of the lakes focused on setting and achieving low enough effluent limits for this element.

Under the Great Lakes Water Quality Agreement of 1972, Canada and the United States, agreed on the necessity for a 1 mg/l limit for phosphorus for all municipal treatment plants which discharge more than one million gallons a day. This limit was the basis for loading requirements for the lower Great Lakes. But the two countries took different routes toward achieving the effluent limit. The Canadian government chose to reduce phosphorus discharges both by treatment and by limiting the phosphate content of detergents.

Because of doubts about possible threats to human health of nitrilotracetic acid (NTA), the chemical which detergent manufacturers had been developing as a potential substitute for phosphorus, the Federal government of the United States elected in 1971 to depend on removal of phosphorus in the treatment of sewage. Experience in Canada, which continued to allow use of NTA, has not confirmed its danger as a carcinogen when used in household detergents. Meanwhile, other substitutes have been successfully used where phosphate bans have been adopted in this country. Several other factors have also caused Region V EPA, which is responsible for the administration of the United States Great Lakes programs, to conclude that it is now necessary to seek removal of phosphates from detergents as well as removal by chemical treatment of sewage and control of nonpoint sources such as land runoff. The following chapters explain why Region V now concludes that banning of phosphates from detergents is not only feasible but essential for both environmental and economic reasons.

The International Joint Commission held its annual meeting in Windsor, Ontario, in July 1976. There the Water Quality Board of the IJC, which had been established under the Agreement, submitted its 1975 annual report on progress toward achieving the objectives. The report, with its four appendices, stressed that, while eutrophication may have slowed somewhat in some places, overall its acceleration beyond natural rates remains a threat to the Great Lakes. The urgency of reducing eutrophication is certain to be a central issue as the required fifth year review of the Agreement continues in 1977. The extent of extreme eutrophication in inland lakes had already been confirmed by EPA's National Eutrophication Survey begun in 1972.

The Water Quality Board report emphasized several factors that had not been appreciated at the time of the original agreement when EPA adopted its policy of dependence on removal of phosphorus by treatment. One factor is that it has now been established that a significant percent of the phosphorus loadings of the lakes is input from the atmosphere. Another is that the tributary loads appear to have been underestimated. Still another is that less has been achieved with the 1 mg/l effluent limit than was hoped for. This is due not only to the delay in completion of some major treatment facilities, Detroit being a prime example, but to the unreliability of phosphorus removal in some facilities which have been brought on line.

The report makes the point that not only is there better understanding now of the present sources of phosphorus loadings, but also a better ability to forcast long term consequences. Several mathematical models have been developed which purport to show that, even if the 1 mg/l effluent limit is achieved consistently at all possible places, the phosphorus loadings to the lakes will still remain so high that eutrophication rates will not be stabilized.

For all these reasons the IJC is now considering whether the effluent limit will have to be lowered to perhaps as little as 0.1 mg/l and should be extended to all municipal plants. As an immediate measure, the report urged adoption of uniform 0.5 percent limit for phosphorus by weight for all detergents manufactured for use in the Great Lakes basin.

In considering what to do in the face of these long term predictions on eutrophication, the Water Quality Board report considered not only the experience with treatment but also the experience with phosphorus bans. Notwithstanding, the national policy, the State of Indiana had adopted a phosphorus ban in 1971 with dramatic and fast improvement for both inland lakes and rivers. The City of Chicago had adopted a ban which the Metropolitan Sanitary District of Greater Chicago estimates that it would cost several million dollars a year in treatment to effect an equivalent reduction in phosphorus. In these locations as well as in the State of New York and in the City of Akron in Ohio, initial consumer resistance to nonphosphate detergents has faded away almost completely. Finally, the rising share of the total detergent market for nonphosphate products throughout the region is evidence of consumer acceptance, though it cannot be known how much the choice of nonphosphate products is related to concern about environmental problems associated with phosphate detergents. For all these reasons, the Water Quality Board recommended that the IJC consider supporting a ban on phosphates in detergents.

Since the Windsor meeting, the IJC has endorsed and submitted the Water Quality Board report to both governments. Recently the phosphorus ban was unanimously endorsed by the Great Lakes Basin Commission. Minnesota has adopted a ban presently being challenged in court which was to go into effect on January 1, 1977. The issue is before the Michigan legislature and the Natural Resources Commission. The issue is being raised in Wisconsin and will soon be raised in Ohio.

Chapter I. Summary and Recommendations

A. Executive Summary

It is essential that resolute and prudent steps be taken immediately to reduce the rate of euhophication of lake waters and streams in the Great Lakes Basin. Some accelerated irreparable changes take place each day where phosphorus loadings exceed the levels that trigger more rapid eutrophication. EPA and its predecessors have worked for more than a decade to reduce effuent levels of phosphorus from municipal point sources in the Great Lakes Basin, but with limited success. The United States has been unable to meet the target loadings set in the 1972 Water Quality Agreement with Canada. Recent studies question whether even these levels will be sufficient to achieve and maintain desired water quality in the Great Lakes.

Reducing the nutrient input is the soundest preventative and restorative measure toward reducing rates of eutrophication. Every nutrient source must eventually be examined for control possibilities, but first attention must be directed to sources that can be controlled now. The urgency of controlling at least some sources of the limiting nutrient phosphorus is the basis for the present intense concern with detergent phosphate bans in the Great Lakes basin.

With present technology, the only readily controllable source of phosphorus input to the environment is sewage effuent. It has not been possible to depend on sewage treatment alone in the Great Lakes Basin for two reasons. Some plants have not attained consistently reliable phosphorus removal. In other cases, phophorus removal equipment cannot be installed where it is needed because of lack of funds or the lack of a municipal sewerage system.

Other sources that cannot be as readily controlled are (1) agricultural runoff, (2) atmospheric deposition, (3) urban runoff through stormwater and other bypass situations, (4) nonpoint sources like shoreline erosion, mining, construction, and silviculture, and (5) and anoxic regeneration from sediments. While greater curtailment of input of phosphorus from sewage effluent is being sought, other sources must be investigated if the water quality desired for lakes and streams in the Great Lakes Basin is to be obtained.

B. Region V Recommendations

Region V, EPA, supports the recommendations of the Great Lakes Water Quality Board of the International Joint Commission and the IJC's confirming recommendations to the governments of the United States and Canada. The appendix at the end of this chapter will briefly describe the mechanisms established under the Water Quality Agreement by which these recommendations are developed. The IJC findings and recommendations are as follows:

1) The present U.S. policy of treatment for phosphorus has not been effective in reducing phosphorus input to Lake Erie and Lake Ontario.

2) Detroit and Cleveland as well as other major metropolitan cities must act quickly to reduce their discharges of phosphorus.

3) The Upper Great Lakes, including Lake Superior, Lake Huron and Lake Michigan must be protected from potential water quality degradation due to accelerated eutrophication associated with high phosphorus levels.

It is hoped that all of the Great Lakes States will consider adoption of a ban on phosphates in detergents. Region V, EPA, will provide technical assistance and expertise on this issue to all regulatory and legislative agencies in the States. Region V will also assist in informing the general public about the reasons for this proposal, including its costs to consumers as well as benefits to the environment. These matters are discussed in detail in the following chapters.

Appendix Mechanisms Established Under the Great Lakes Water Quality Agreement Through Which the IJC Develops its Recommendations

The U.S./Canada Agreement on Great Lakes Water Quality of 1972 was signed by both governments on the basis of the premise that the governments adopt common water quality objectives. The best means of meeting this commitment was identified as the implementation of cooperative programs toward the goal of achieving improved water quality in the Great Lakes.

Eutrophication was one of the key problems identified by earlier IJC studies on the Great Lakes. This problem resulted in the identification of phosphorus as one of the specific water quality objectives of the Agreement, although no specific number was set. The Agreement, did however, go on to highlight phosphorus in Annex 2, which includes an effluent limitation and a load allocation for phosphorus to the Great Lakes.

It is important to understand the mechanisms by which the IJC, through its investigative and recommendatory functions, places Great Lakes water quality issues before the governments.

The Agreement assigned specific responsibilities, functions and powers to the IJC and provided for joint institutions to support it. The principal institution is the Water Quality Board, although a Research Advisory Board, an Upper Lakes Reference Group and a Pollution from Land Use Activities Reference Group were established as well.

The Agreement calls for the Water Quality Board to focus its own investigative and recommendatory functions, through an intense and continuing assessment, on the strength and quality of the U.S. and Canada programs being implemented to meet the Agreement. Thus, the Water Quality Board provides an overview to the IJC of all of the pollution related activities on the Great Lakes.

The Water Quality Board consists of one federal member from U.S. EPA as Co-Chairman, and includes membership from all eight Great Lakes States. U.S. membership is matched by an equal number of Canadians from federal and provincial levels. The principal subordinate units of the Water Quality Board are the Implementation Committee and the four subcommittees on Surveillance, Remedial Programs, Water Quality Objectives and Radioactivity. The Board is required to prepare an annual report to the IJC on water quality in the Great Lakes, utilizing the broad range of expertise available from the joint governments who hold membership on the committees. The IJC then prepares its own report to the respective governments, reflecting the substance if not the letter of the Board's report. The governments can then implement (or ignore) these recommendations. If the recommendations are beyond the scope of existing legislation, the governments can seek legislation to carry the recommendations out.

Chapter II. Background of Phosphorus Control Policy

A. LIMITING NUTRIENT CONCEPT

Control of eutrophication depends on the limiting nutrient concept. This concept is based on Leibig's Law of the Minimum that "growth is limited by the substance that is present in minimal quantity in respect to the needs of the organism." While physical factors such as light penetration and temperature and chemical factors such as toxicity may limit growth in surface waters unaffected by human activity, phosphorus is normally the nutrient that limits algae production.

B. REDUCTION OF PHOSPHORUS LOADINGS

Phosphorus as phosphate is essential for plant nutrition. In excess of a critical concentration, phosphates stimulate plant growths. During the past 30 years, standing crops of aquatic plants have increased enough to interfere with water uses and become nuisances to man. Such phenomena are associated with accelerated eutrophication, or aging of waters. It is recognized that phosphorus is not the sole cause of eutrophication but there is substantial evidence that generally it is naturally present in the least amount relative to need. Therefore, an increase in phosphorus allows use of other nutrients already present for plant growth. If other elements such as silicon are depleted, a shift in algal species will occur. Often blooms of nuisance bluegreen algae will develop. Of all of the elements required for plant growth in the water environment, phosphorus is the most easily controlled by man.

Table 2-1 From Vallentyne, illustrates this point:

Table 2-1 *Comparison of Various Plants Nutrients in Respect to (A) Whether They are Ever Growth-Controlling in Lakes and (B) Whether They are Controllable by Man. Elements Listed in Order of Increasing Atomic Weight. Note that Phosphorus is the Only Element Meeting Both Requirements.

Nutrient	A	B	Nutrient	A	B
Hydrogen	no	no	Chlorine	no	no
Boron	no	no	Potassium	no	no
Carbon	rarely	no	Calcium	no	no
Nitrogen	yes	partly	Manganese	sometimes	no
Oxygen	no	no	Iron	sometimes	no
Sodium	no	no	Cobalt	rarely	no
Magnesium	no	no	Copper	no	no
Aluminum	no	no	Zinc	no	no
Silicon	yes**	no	Molybdenum	sometimes	no
Phosphorus	yes	yes	Iodine	no	no
Sulphur	rarely	no			

*Vallentyne J.R. 1970, Phosphorus and the control of eutrophication. Canadian Res. & Development 3: 36-43, 49.

**Diatoms only

Evidence indicates that: (1) high phosphorus concentrations are associated with accelerated eutrophication of waters, when other growth promoting facts are present; (2) aquatic plant problems develop in reservoirs and other standing waters at phosphorus values lower than those critical in flowing streams; (3) reservoirs and lakes collect phosphates from influent streams and store a portion of them within consolidated sediments, thus serving as a phosphate sink; and, (4) phosphorus concentrations critical to noxious plant growth vary, and nuisance growths may result from a particular concentration of phosphate in one geographical area but not in another. The amount or percentage of inflowing nutrients that may be retained by a lake or reservoir varies with: (1) the detention time within the lake basin or the time available for biological activities; (2) the extent of biological activities; (3) the volume of the euphotic zone; (4) the nutrient loading to the lake or reservoir; and (5) the rate of discharge from the lake or from the reservoir.*

Phosphates enter waterways from several different sources. The human body excretes about one pound per year of phosphorus expressed as "P". Current use of phosphate detergents and other domestic phosphates increases the per capita contribution to about 2 1/2-3 pounds per year of phosphorus as P. The major phosphorus ingredient from detergents is soluble tripolyphosphate which is readily available for biological activities. This increases its significance relative to its percentage of total phosphorus. Some industries have wastewaters high in phosphates. Crop, forest, idle, and urban land contribute varying amounts of phosphorus from diffuse sources by drainage into watercourses. This drainage may be surface runoff of rainfall, or effluent from tile lines. Shoreline erosion, anoxic regeneration from sediments, tree leaves, and fallout from the atmosphere all are contributing sources.

Once nutrients are available within the aquatic ecosystem, their removal is tedious and expensive. Phosphates used by algae and higher aquatic plants may be stored in excess of use within the plant cell. With decomposition of the plant cell, some phosphorus may be released immediately through bacterial action for recycling within the biotic community, while the remainder may be deposited with sediments. Much of the phosphorus that becomes combined with the consolidated sediments within the lake bottom is bound permanently and will not be recycled into the system. However, sediments can act as a reservoir of phosphorus should widespread anoxic conditions develop.

LAKE ENRICHMENT

The response of lake systems to nutrient loadings or different rates of enrichment depends on the depth, flushing time, surface area, and bottom sediment type of the lake. The response of aquatic plants to enrichment determines the trophic nature of the lake which is the basis for lake classification as oligotrophic, mesotrophic, or eutrophic. Figure 2-1** shows in general terms the relationship between trophic state and water quality conditions. Figures 2-2** and 2-3** show the chlorophyll α and the total phosphorus concentrations, respectively, of selected areas of the Great Lakes System.

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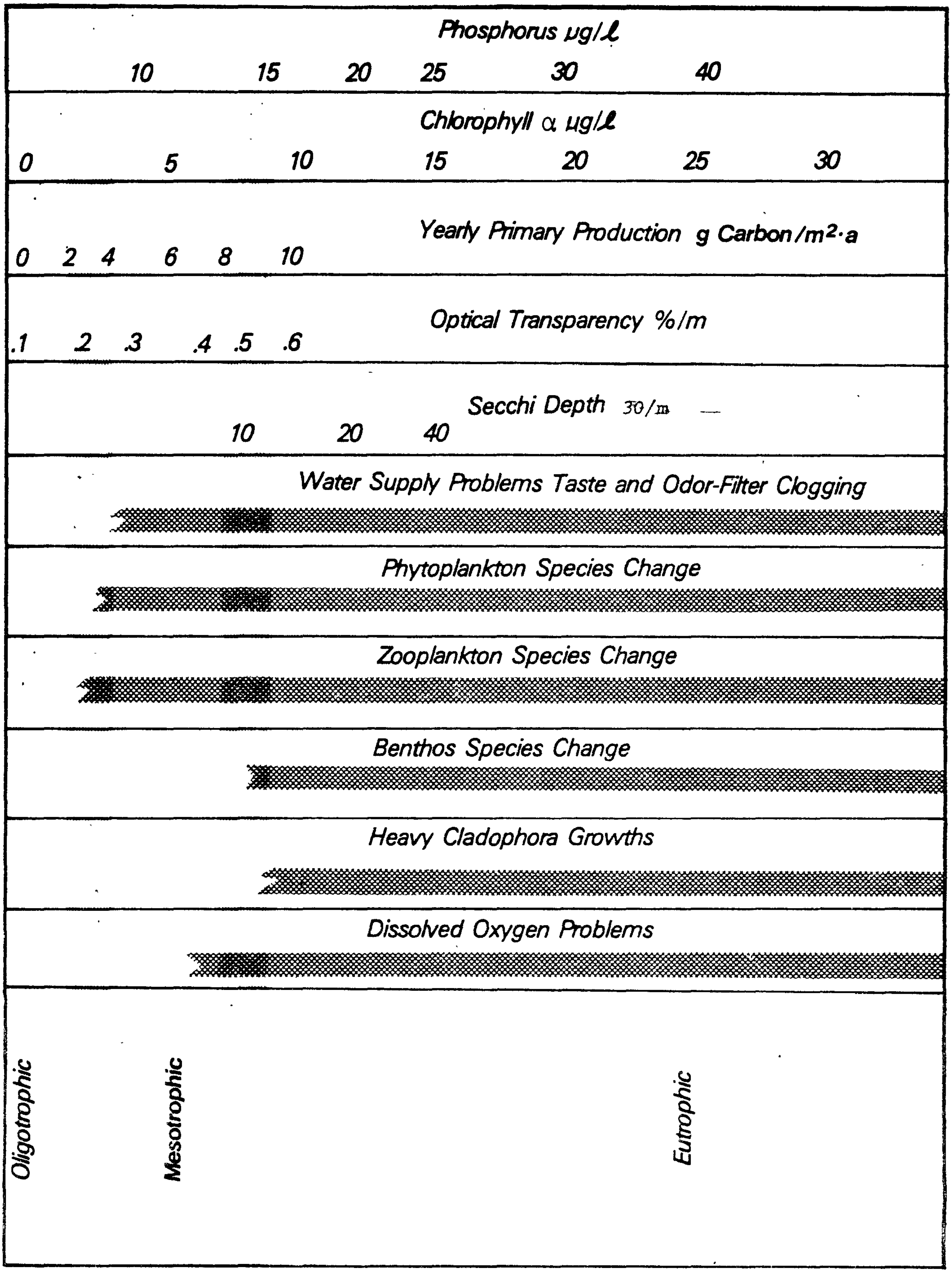
* 1976 Quality Criteria for Water -- U.S. EPA -- Washington, D.C. 20460, Pre-publication Copy, p353-359; Substantial material for this and following two paragraphs was drawn from this source.

** 1976 IJC Upper Lakes Reference Group. The waters of Lake Huron and Lake Superior, Volume I, Summary and Recommendations, pg 128, 112, & 129.

FIGURE 2-1

ENRICHMENT PROBLEM RELATIONSHIPS



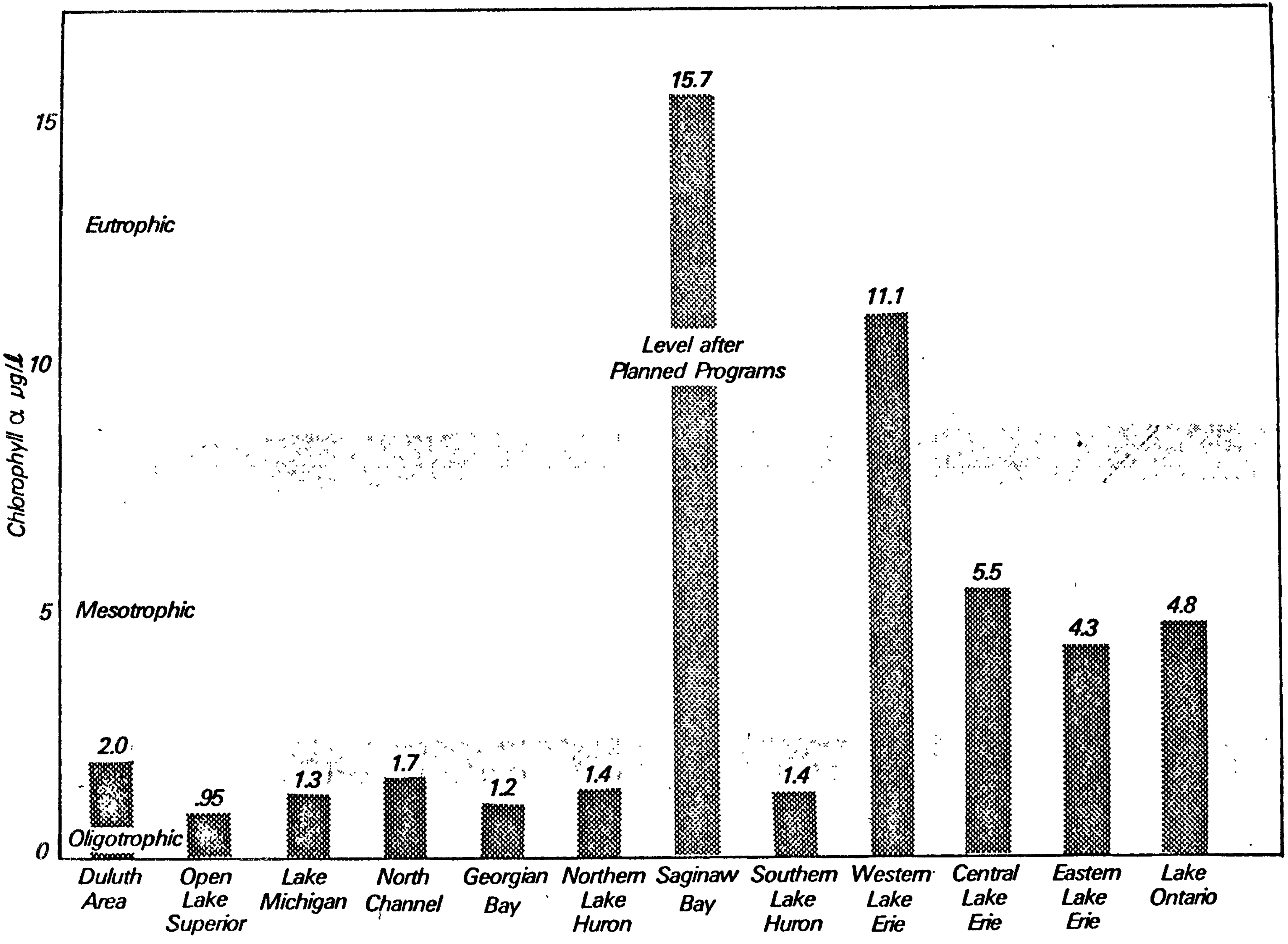


FIGURE: 2-2 TROPHIC STATUS OF THE GREAT LAKES BASED ON CHLOROPHYLL α

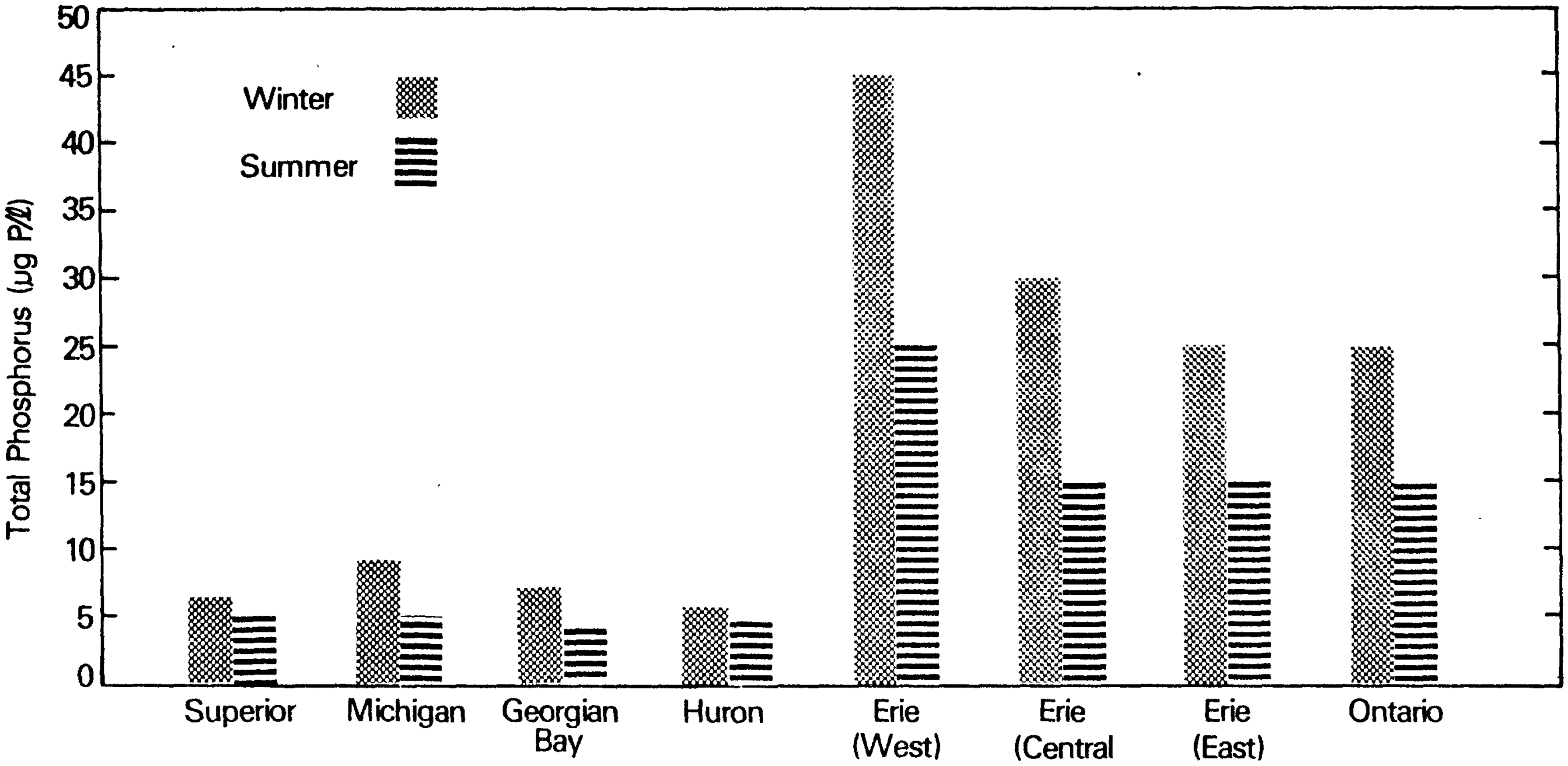


FIGURE 2-3 **TOTAL PHOSPHORUS** CONCENTRATIONS IN THE OPEN WATERS OF THE GREAT LAKES

Since enrichment takes place at specific shore locations - either cultural point sources (and regions) or tributary mouths - and since there is a dilution effect as one moves further from the source, the impact varies with location in a lake. It is most severe in embayments or harbors. Time scales of reaction to changes in enrichment rates also vary. Nearshore or embayment areas in the Great Lakes already show impact from the increased enrichment (inflow concentrations of total phosphorus exceeding 30 to 40 mg/l) of recent years. Only subtle changes can be detected in the open waters of the lakes where changes are both smaller and longer in developing, though equally significant. A key factor influencing the trophic state of a lake is the rate of supply of phosphorus to that lake. All phosphorus sources are implicated in the nutrient supply of a well-mixed system.

The nearshore-offshore exchange processes are inadequately understood and in-depth study is required if man is to manage the Great Lakes. Without thorough understanding of these exchange phenomena, very careful conservative management which would not lead to degradation of this high quality water resource is essential.

GREAT LAKES SITUATIONS AND CURRENT TARGET LOADINGS

LAKE SUPERIOR *

Lake Superior is oligotrophic (Figure 2-4) with chlorophyll levels of 1 ug/l levels (Figure 2-2) and total phosphorus concentrations of 3-5 ug/l (Figure 2-3). In order to maintain present water quality and taking into account that the lake is not in equilibrium with present loadings, the calculated loading must not exceed 3900 t/a to prevent accelerated eutrophication. Table 2-2 summarizes the present and projected loadings of phosphorus to Lake Superior. Present loading from point sources is only 15% of the total.

The planned reductions of 200 t/a will come close to maintaining the present water quality of Lake Superior. In order to achieve the objective of 3900 t/a and with future development, it will be necessary to install maximum phosphorus controls at all municipal and industrial sources. Additional control can be achieved through reductions of phosphorus in detergents (P-Ban) and by reducing nonpoint source inputs. The maximum estimate of possible reductions with a P-Ban is 60 t/a (see table 2-3).

The Duluth-Superior Harbor exhibits definite signs of enrichment. In addition, there is nutrient buildup in local areas at Munising, Marquette, and Thunder Bay. Adequate treatment and phosphorus removal will alleviate this water quality degradation; facilities are being installed for the three U.S. areas.

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* Op. Cit. - The Waters of Lake Huron and Lake Superior, p 137

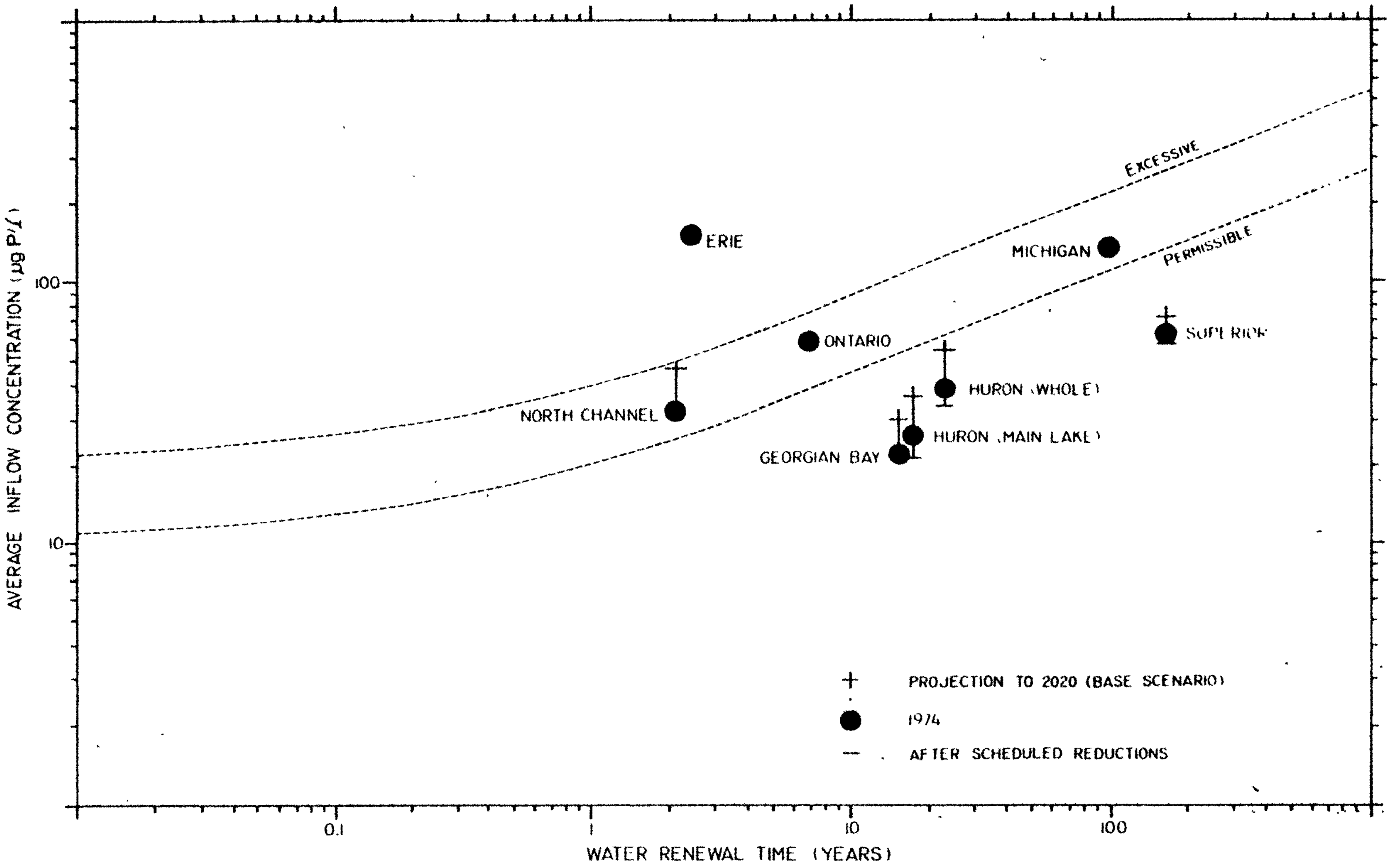

FIGURE 2-4 TROPHIC STATUS OF THE GREAT LAKES

Table 2-2 PHOSPHORUS LOADINGS [METRIC TONS/ANNUM]

	Superior[1]		Huron[2]		Erie[3]		Ontario[7]		Michigan	
Source	1974	Scheduled	1974	Scheduled	1974	Recommended	1974	Scheduled	1974	Recommende
Outflow From Other Lakes	---	---	863	863	2334	2334	6680	6680		
Atmospheric	800	800	450	450	560[4]	560[4]	350[4]	350[4]	1000[9]	1000[9]
Shoreline Erosion	280	280	--	--	--	--	--	--		
Municipal	480	280	1014	314	8442	3638	--	--	2916[10]	
Direct	132		70		6529		1908	2276	1088[11]	
Indirect	348		944		1913				1828[12]	
Industrial	120	120	70	70	120		116	--	45[11]	
Direct	99		67		120				45[11]	
Indirect	21		3		0					
Nonpoint Source (land run off in basin)	2460	2460	1323	1323	8711	6553	3711	--	3139[12]	
Anoxic Regeneration	--	--	--	--	2100[5]	2100[5]	--	--		
	4140	3940	3720	3020	19607[6]	12525[6]	12415[8]	9931[8]	7100	5350[13]

Table 2-2

1.	1976 IJC	Upper Lakes Reference Group Volume I - The Waters of Lake Huron and Lake Superior - Summary and Recommendations, pp. 54 and 138
2.	1976 IJC	Upper Lakes Reference Group Volume I - The Waters of Lake Huron and Lake Superior - Summary and Recommendations, pp. 52 and 133
3.		Lake Erie Wastewater Management Study - Preliminary Feasibility Report Volume 1 Main Report pp. 57 and 157
4.	1975 IJC	Great Lakes Water Quality Board Appendix B - Surveillance Subcommittee Report p. 107
5.	1975 IJC	Great Lakes Water Quality Board Appendix B - Surveillance Subcommittee Report p. 69
6.		Does not include atmospheric and anoxic regeneration
7.	1975 IJC	Great Lakes Water Quality Board Appendix B - Surveillance Subcommittee Report p. 209
8.		Does not include atmospheric
9.	1976	Murphy T.J., and Doskey P.V. 'Inputs of Phosphorus from Precipitation to Lake Michigan' International Association for Great Lakes Research Journal of Great Lakes Research Vol 2 No 1 p 60
10.	1974 IJC	Great Lakes Water Quality Board Appendix C - Remedial Program Subcommittee - Table 18 p72
11.	1974 IJC	Great Lakes Water Quality Board Appendix C - Remedial Program Subcommittee Report-Table 6 p60
12.		By computation - See references in 10 and 11.
13.	1973 IJC	Great Lakes Water Quality Board Annual Report - Table 13 p89 (does not include atmospheric)

Lake	Ta Phos L
Superior	39
Huron	36
Erie	14 12
Ontario	90 74
Michigan	53

1 IJC, Upper Lak
2. IJC, Upper Lak
3. 1972 Great Lak
4. Corps of Engin
Plan 9, Vol. 1
5. 1972 Great Lak
6. IJC, Water Qua
B, Fig 3;55

LAKE HURON (MAIN LAKE) *

The Lake Huron Basin contains three distinct water bodies: the North Channel, Georgian Bay, and Lake Huron proper. These different bodies act semi-independently and are therefore discussed separately.

The trophic state of Lake Huron can be expressed in terms of total phosphorus loading and the volume and water renewal time for that lake. For Lake Huron proper, exclusive of Georgian Bay and the North Channel, this can be represented as a point on the Vollenweider chart relating average inflow concentration to the water renewal time (Figure 2-4). On this basis, Lake Huron proper is classed as oligotrophic; this is confirmed from examination of several other criteria. Principal among these criteria are the low chlorophyll α concentrations (1 to 2 ug/l, Figure 2-2), low phosphorus concentrations (3.5 to 5.5 ug/l, Figure 2-3), the domination of phytoplankton assemblages by diatoms and microflagellates throughout the year, minimal oxygen depletion in the hypolimnion in summer stratification, and in secchi disc readings of 8 m. However, there is summer nutrient depletion in the epilimnion, indicating approaching mesotrophy.

In order to maintain present water quality as indicated by a chlorophyll α concentration of 1.4 ug/l, the calculated loading as predicted by eutrophication models must not exceed 3600 t/a. Table 2-2 summarizes the present and projected loadings of phosphorus to the main body of Lake Huron. The present total loading is 3720 t/a, of which 29% is due to cultural point sources. These sources are being subjected to additional control (particularly for inputs to Saginaw Bay), which will reduce phosphorus loading from its present 3720 t/a to 3020 t/a. This level of loading is adequate to protect the present trophic state of the lake. However, the potential for future cultural enrichment is large, as indicated by projections to the year 2020, even with maximum phosphorus controls of all municipal and industrial sources. Therefore increased controls on other sources, which account for 71% of the present phosphorus inputs, will be necessary. These include contributions from land use activities, atmospheric inputs, Lake Superior, Lake Michigan, the North Channel, and Georgian Bay. Table 2-3 indicates the anticipated load reduction from P-Ban.

Of the total phosphorus loading to Lake Huron proper, ∼ 70% is retained within the lake, primarily in the sediments. Only one fourth is effectively passed on to the Lower Lakes.

Very few nearshore areas of Lake Huron proper can be considered eutrophic. The one exception is Saginaw Bay, which receives wastes from about 1,200,000 persons, as well as from industry and from rural drainage from intensively farmed land. The Saginaw River contributes 30% of the total phosphorus which enters the main body of Lake Huron. This elevated loading has resulted in extremely enriched conditions in Saginaw Bay compared with other areas of the Great Lakes system. Total phosphorus concentrations of up to 0.058 mg/l have been measured from 1965 to 1974 (compare with Figure 2-3).

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*Op. Cit. - The Waters of Lake Huron and Lake Superior, p 133.

The average chlorophyll concentration in Saginaw Bay is 15.7 ug/l (Figure 2-2). Taste and odor problems within the Saginaw - Midland, Bay City, and Pinconning Michigan water supply systems and filter cloggings at two of the three municipal intake sites on Saginaw Bay have been a problem for a number of years. Forty-two percent of the threshold odor measurements taken at the public water supply intake at Whitestone Point equalled or exceeded the U.S. drinking water standard of three. Reductions in loading of essential algal nutrients should indirectly assist in bacteria population regulation which are involved in taste and odor problems in the Great Lakes. The substantial nutrient inputs to Saginaw Bay require effective control if enrichment in Saginaw Bay is to be reversed.

A high portion of the phosphorus input to, and the algae produced in Saginaw Bay, escape to the open lake; thus, reduction of phosphorus loading to Saginaw Bay will improve water quality in both Saginaw Bay and the open lake. Model projections for Saginaw Bay indicate reductions in blue-green algae and phosphorus concentrations proportional to reductions in phosphorus loading. Currently planned programs will reduce phosphorus loading from 1300 t/a to 700 t/a. This is expected to reduce the phytoplankton standing crop by 33% (Figure 2-2).

Goedrich, Cheboygan, Alpena, and Harbor Beach are four small areas impacted by nutrient inputs; phosphorus removal would alleviate enrichment problems, and is being implemented at the last three locations.

GEORGIAN BAY

The criteria for trophic state indicate that Georgian Bay, as a whole, is oligotrophic (Figure 2-4). The chlorophyll α concentration averages 1.2 ug/l (Figure 2-2) and the total phosphorus concentation is $\sim$8.0 ug/l (Figure 2-3). The present phosphorus loading is 928 t/a of which more than 90% is from atmospheric and nonpoint sources. Georgian Bay acts as an effective sedimentation basin for phosphorus with 90% of that entering the bay eventually being lost to the sediments. This 90% effective removal benefits the main body of Lake Huron substantially. Future trophic control in Georgian Bay will be difficult since phosphorus removal is already in place at municipal treatment plants around the bay. Canada has reduced the phosphorus content of laundry detergent to a maximum of 2.2% phosphorus. Maintenance of water quality in Georgian Bay will require nonpoint source controls.

There is localized enrichment at Midland Bay, Penetang Bay, and Collingwood Harbor. Phosphorus removal is not operational at municipal treatment plants in these locations and should lead to improvements in water quality. The expected improvements in these bays should be the subject of surveillance.

NORTH CHANNEL

Phosphorus loadings to the North Channel are well up into the mesotrophic range (Figure 2-4). Chlorophyll α concentrations average 1.7 ug/l (Figure 2-2). The principal cause is loading from the St. Marys River and from local tributaries. The phosphorus loading to the North Channel is expected to increased from its present level of 1220 t/a. Maintenance or improvement of the water quality in the North Channel can only be accomplished through nonpoint source controls.

LAKE MICHIGAN

The loading rate of phosphorus into Lake Michigan and concentrations of this nutrient confirms that certain areas of the Lake are exhibiting cultural eutrophication. Lake Michigan's nearshore, embayments, and southern parts, would be classified as mesotrophic or eutrophic while the open waters, especially, in the northern parts of the Lake, are oligotrophic with a tendancy towards mesotrophic. Indicators of trophic status for the entire lake suggest that Lake Michigan is a mesotrophic body of water. The phosphorus loadings to Lake Michigan are well up into the mesotrophic range (Figure 2.4). Total phosphorus concentrations in the open waters during winter are in the mesotrophic range (Figure 2-3). Chlorophyll α levels of 1.3 ug/l levels (Figure 2-2) are close to the lower boundary of the mesotrophic range.

It is predicted by Tarapchak and Stoermer in Environmental Status of the Lake Michigan Region, Vol. 4, Phytoplankton of Lake Michigan (in press), that if Lake Michigan's phosphorus load continually increases, the rate of eutrophication will accelerate, and nitrogen and light will eventually become factors limiting phytoplankton growth. Such conditions presently occur in Green Bay, a body of water characterized by nuisance blooms of blue-green algae. Increased nutrient loadings generally affect the shallow, inshore regions first. Gradually, offshore water is altered and exhibits symptoms of cultural eutrophication induced by sustained nutrient inputs into the nearshore environment. Data on concentrations and loading rates of phosphorus, nitrogen, and silica suggest that the present pattern of cultural eutrophication in Lake Michigan is similar to that proposed for large lakes by Beeton and Edmondson (1972), as cited by Tarpchak and Stoermer, op. cite.

In order to meet the target phosphorus load, the present total load of 7100 t/a of which 42% is due to cultural point sources must be reduced. These sources are being subjected to additional control which should reduce phosphorus loading by 1145 t/a from its 1974 level. These reductions alone will not be sufficient to meet the recommended loading.

Estimated residual loads after P-Ban and 1 mg/l treatment apppear to be sufficient to achieve the total lake target load based on present loading estimates (see Table 2-3). These reductions in phosphorus loading to the lake should result in significant improvements in nearshore, and eventually, offshore water quality. Local improvements in Lake County Illinois and north Chicago have occurred as the result of abatement programs. However, inshore regions in the southern basin, near Milwaukee, and in southern Green Bay presently exhibit clear signs of advanced eutrophication resulting from large supplies of phosphorus received from polluted tributaries.

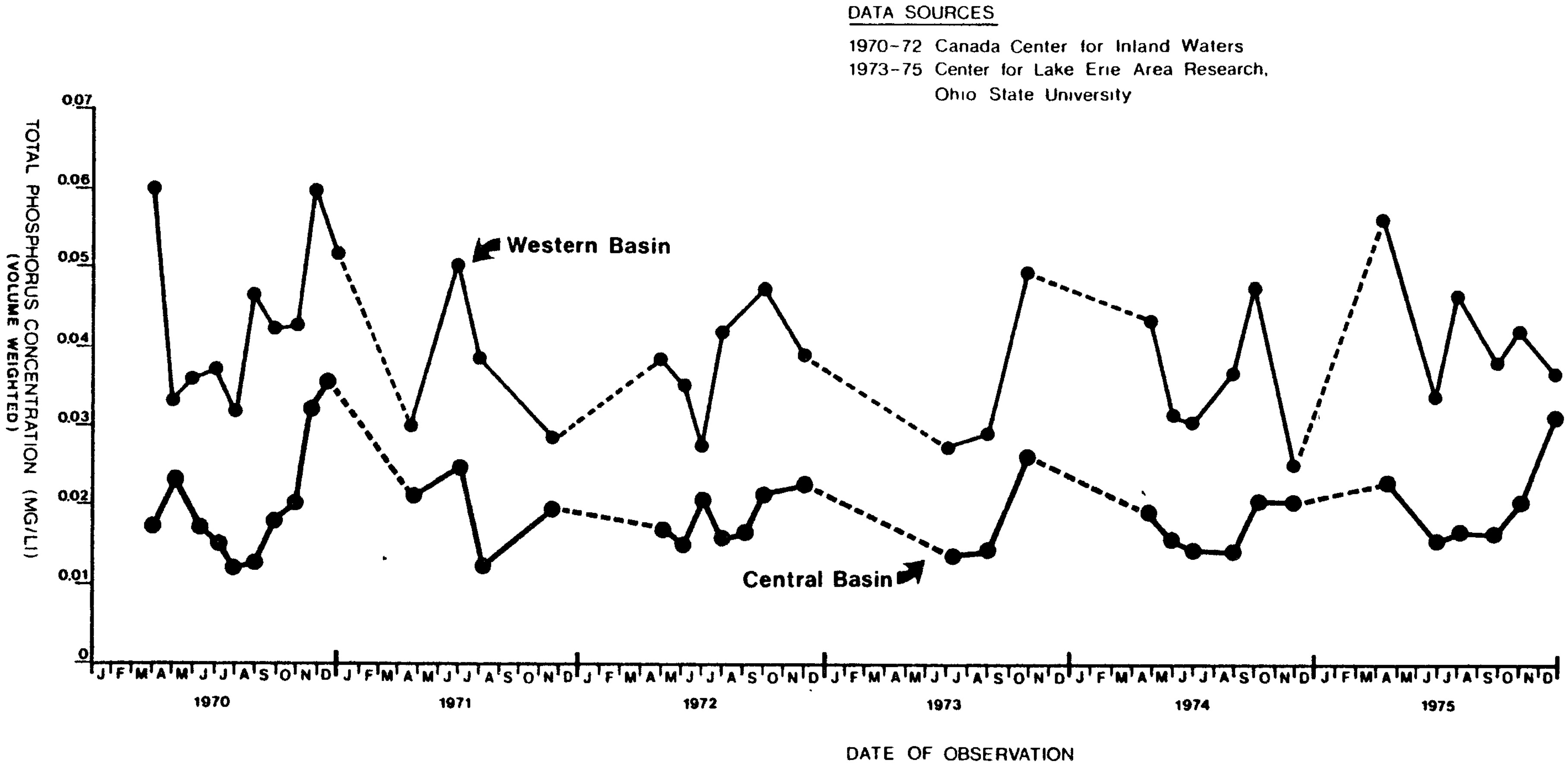
LAKE ERIE

Lake Erie, because it is the most eutrophic of the Great Lakes, is of particular public interest. Its classification as eutrophic is indicated, by its position on a Vollenweider-type diagram (Figure 2-4), where influent phosphorus is related to water renewal time for the lake. Figure 2-2 confirms this classification for the Western Basin of Lake Erie where the average chlorophyll α concentration of 11.1 ug/l places it in the eutrophic range. In the Central and Eastern Basins, average chlorophyll α concentrations are 5.5 and 4.3 ug/l, in the mesotrophic range. Another factor which enter into the classification is the lack of dissolved oxygen in the hypolimnion of the Central Basin.

In view of the wide public interest in the condition of Lake Erie, a review of progress in controlling pollution of the Lake is presented. According to a 1974 report of the Surveillance Subcommittee of the Water Quality Board,

Figure 2-5

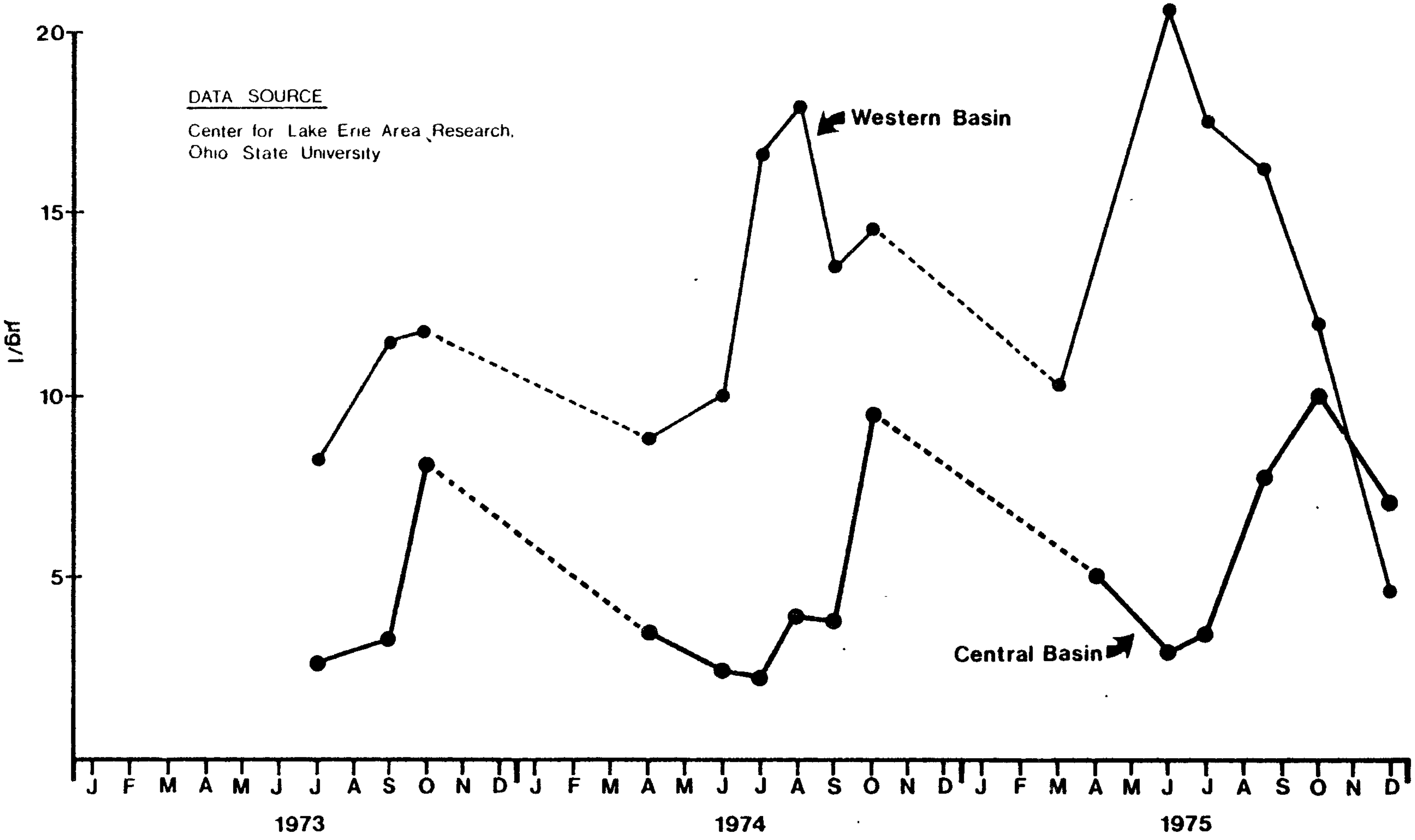
TOTAL PHOSPHORUS CONCENTRATIONS IN LAKE ERIE 1970-1975



DATA SOURCES

1970-72 Canada Center for Inland Waters
1973-75 Center for Lake Erie Area Research, Ohio State University

Figure 2-6 VOLUME WEIGHTED CONCENTRATION (μG/L) OF CORRECTED CHLOROPHYLL a IN LAKE ERIE 1973-1975



DATA SOURCE

Center for Lake Erie Area Research,
Ohio State University

"Lake Erie appears, on the whole, to be no longer deteriorating, having stabilized at a still undesirable condition."

Though phosphorus loadings are still far from the target levels scheduled under the 1972 Agreement, there has been considerable progress in reducing loadings. For example, loadings from the Detroit River have declined from 33 thousand t/a in 1968 to 12 thousand t/a in 1975, though most of this reduction occurred before the Agreement went into effect. In the period covered by the Agreement, overall loadings to the Lake have declined 30% from about 28,304 t/a in 1971 to 19,607 t/a in 1974-75. Though the latter is still considerably higher than the target loads for 1975 and 1976 (15,240 t/a and 14,606 t/a, respectively), two-thirds of the reduction targeted by 1975 had been achieved.

The minimum summer phosphorus mass appears to have increased over the past six years (Figure 2-5).* Trends have not been found in chlorophyll α concentrations for the past three years (Figure 2-6).*

Two other aspects of Lake Erie's are of interest. First, the Surveillance Subcommittee has observed some shifts over time in zooplankton and macroinvertebrates toward warm-water and pollution-tolerant forms.**

Secondly, with regard to an aspect of Lake Erie's condition which has received wide attention, the area of the Central Basin hypolimnion which become anoxic - a state of no dissolved oxygen - reached a peak in 1973 at 94% and declined dramatically in 1975 to 6%. However, this does not indicate a definite improvement in the Lake since the 1975 result is due to the spring weather conditions which prevailed and its effect on the thermal structure of the Lake. The anoxic area has an effect on biota, and can cause phosphorus in the sediment to go back into solution. In 1976, the area of anoxic was 63%.

In a study authorized under P.L. 92-500, the U.S. Corps of Engineers concentrated on analyzing present sources and quantities of phosphorus loadings to the Lake. For 1974-75, the total phosphorus loading rate is estimated to be 19,607 t/a. Table 2-2 summarizes the phosphorus loadings from various sources.

In the Corps' study, a mathematical model was used to predict equilibrium phosphorus concentrations in each basin under various loading scenarios. This model which assumes the Lakes' three major basins to be "completed-mixed reactors" in series and assumes various physical, chemical and biological transformations of phosphorus within each reactor, was used to predict equilibrium phosphorus concentrations in each basin under various loading scenarios.

The Corps considers that, in order to return Lake Erie to a mesotrophic state, the phosphorus concentration in the Western Basin must be reduced from the present 0.037 mg P/l to 0.020 mg P/l, the Central Basin from 0.018 mg P/l to 0.015 mg P/l and the Eastern Basin from 0.022 mg P/l to 0.015 mg P/l. To achieve these in-lake concentrations, the study concluded that loadings to the lake must be reduced to 12,525 t/a. The study concluded that these conditions could be achieved in 1-6 years after an adequate reduction in applied phosphorus loadings. However, scheduled elimination of municipal and industrial point dischargers of phosphorus will not be sufficient to achieve this (see Table 2-3) since a 44% of the present loadings is estimated to come from diffuse sources such as land runoff.

* 1975 IJC Water Quality Board Report - Appendix B Surveillance Subcommittee Report, p 73 and 74.

** 1974 IJC Water Quality Board Report - Appendix B Surveillance Subcommittee Report, p 103.

The Corps is continuing its study in order to develop an economically and technically feasible program to achieve the desired reductions in phosphorus loading to Lake Erie and, in cooperation with EPA, is attempting to model phosphorus loadings and lake conditions as they change over time.

While much is yet to be learned about the lake, it is worth noting that a P-ban would have a significant effect on loadings. As mentioned, present P-loads are 19,607 t/a in contrast to the WQ Agreement target of 14,606 t/a, a difference of 5,000 t/a. A P-ban in Michigan would approximately halve the gap, a reduction of about 2,500 t/a.

LAKE ONTARIO

Lake Ontario is classified as a mesotrophic lake (Figure 2-4). Figure 2-2 confirms this evaluation with average chlorophyll α concentration at 4.8 ug/l in the mesotrophic range. In order to maintain present water quality and taking into account that the lake is not in equilibrium with present loadings, it is calculated that loading must not exceed 7450 t/a,* a lower target load than previously. Table 2-2 summarizes the estimated phosphorus loading. The present loading from point sources is about 16% of the total. The planned reductions (Table 2-3) from 1 mg/l effluent requirements of 2,486 t/a in the Lake Ontario basin and 3751 t/a, if the Lake Erie reductions can be anticipated, will not be sufficient, based on current P-loads and lowered target load. Estimated residual loads after P-ban in the Lake Erie Basin and 1 mg/l treatment are still insufficient to achieve the lowered target load. The additional reductions with treatment to achieve a 0.1 mg/l effluent limit could be sufficient based on current estimates (see Table 2-3). However, as technology becomes available, phosphorus inputs from presently uncontrolled sources, the atmospheric sources, land drainage, lake sediments and shore erosion will all need to be reduced.

CONCLUSIONS

With the long flushing times and effective mixing of the Upper Lakes, the general trophic states of Lake Superior and the main body of Lake Huron are the result of loading from all sources. In contrast to the Lower Lakes (and with the exception of Saginaw Bay), cultural inputs of phosphorus do not dominate the present loading, though their significance could increase in the future.

Embayments and harbors are the isolated cases of presently identified enrichment impact, with the exception of Saginaw Bay which has a measurable and distinct impact on southern Lake Huron. However, these embayments and harbors are the focus of local efforts to clean up pollution.

In the face of projected development, to maintain the present or the reduced levels of loading (see Table 2-3), the reduction of atmospheric or land use inputs will be required to prevent degradation of these fresh water bodies.

For the Lower Lakes, the United States is behind schedule in reducing loadings under the 1972 Water Quality Agreement with Canada. The reductions in phosphorus loadings to Lake Ontario and Lake Erie anticipated in the Agreement are not likely to be met. New estimates of the response of these

*Op. Cit. 1975 IJC Water Quality Board Report - Appendix B, Figure 3:55, p 221 lakes indicate the likelihood of delayed recovery in response to current scheduled phosphorus reductions and the growing recognition of the importance of nonpoint sources of phosphorus. Although further reductions in phosphorus loadings from municipal and industrial sources are possible after achieving 1 mg/l P, significant amounts are entering the lakes from the atmosphere, lake sediments and land drainage.

REQUIREMENTS ON PHOSPHORUS CONTROL

The 1972 Agreement set target loadings for municipal treatment plants for the Lower Lakes which called for effluent limitations of 1 mg/l for plants discharging over 1 MGD. All of the States in the Great Lakes Basin have established phosphorus effluent limitations.

A brief list of the current effluent requirements on municipal plants to protect downstream water uses is:

Illinois	1 mg/l in the Lake Michigan Basin and in the Fox River Basin for plants over 1500 population. Illinois municipalities no longer discharge to Lake Michigan Basin.
Indiana	80% removal or 1 mg/l whichever is more stringent if the discharge is in the Great Lakes Basin or within forty miles of a lake or reservoir and discharges ten or more pounds of phosphorus per day.
Michigan	80% removal or 1 mg/l
Minnesota	1 mg/l if discharge is directly to or affects a lake or a reservoir.
New York	1 mg/l
Ohio	1 mg/l or stricter requirements set by OEPA-NPDES permits in Lake Erie Basin, and in all waters tributary to the Ohio River and its basin where nuisance growths exist.
Penna	1 mg/l
Wisconsin	85% removal for plants over 2500 population in the Great Lakes Basin.

A recent summary of the current status for removal of phosphates from detergents in the Great Lakes is shown in Table 2-4.

TABLE 2-4

STATUS OF LEGISLATION TO LIMIT THE PHOSPHORUS CONTENT OF DETERGENTS USED IN THE GREAT LAKES BASIN

JURISDICTION	POPULATION (1970)		DETERGENTS PHOSPHORUS LEGISLATION		
	(in Great Lakes Basin)	Date Effective	Allowable P (%)	Detergents Included	References
New York	3,517,992	01/72 to 07/73 07/73	8.7% 0.5%	-household use, laundry use, other personal uses, industrial uses <u>except</u> those for machine dishwasher, dairy equipment, beverage equipment, food processing equipment and industrial cleaning equipment.	1
(Erie County)	(1,103,414)	05/71 to 01/72 01/72	8.7% 0.5%		2
Michigan	8,780,119	07/72	8.7%	-<u>all</u> cleaners	3
(Detroit)	(4,199,931)	(07/72)	(0.5%)	-(City ordinance enacted but pre-empted by Act 226 - State of Michigan above).	4
Indiana	1,291,125	01/72 to 01/73 01/73	8.7% 0.5%	-does <u>not</u> include detergents for cleaning in-place food processing and dairy equipment; phosphoric acid products including sanitizers, brighteners, acid cleaners and metal conditioners, detergents for use in dish washing machine equipment, including household and commercial machine dishwashers, detergents for use in hospitals and health care facilities; industrial laundry detergents, detergents for use in dairy, beverage, food processing and other industrial cleaning equipment.	5

TABLE 2-4 (continued)

STATUS OF LEGISLATION TO LIMIT THE PHOSPHORUS CONTENT OF DETERGENTS USED IN THE GREAT LAKES BASIN

JURISDICTION	POPULATION (1970) (in Great Lakes Basin)	Date Effective	DETERGENTS PHOSPHORUS LEGISLATION		References
			Allowable P (%)	Detergents Included	
Minnesota	236,805	01/77	0.5%	-all household cleaning agents intended to be used in the home, laundry detergents and built soaps for machine laundry except chemical water conditioners and household and commercial detergents for machine dishwashing.	6
		01/77	11%	-household and commercial detergents for machine dishwashing.	6
Ohio	4,259,247	None			
Akron	(679,239)	01/73	0.5%	-total ban	7
Pennsylvania	235,998	None			7
Erie	232,074	None			7
Wisconsin	2,456,351	None			7
Illinois	4,618,598	None			7
Chicago	(4,618,598)	07/72 to 03/73	0.5%	-household laundry detergents	8
Canada	6,376,955 (1971)	07/70 to 01/73	8.7%	-laundry detergents	9
		01/73	2.2%		9

TABLE 2-4

REFERENCES

1. Eberly, W.R., "History of the Phosphate Detergent Ban in Indiana," Proceedings of the Indiana Academy of Science for 1974, Vol. 84, 1975, pg. 410.

2. Hopson, N.E., "Phosphorus Removal by Legislation," *Water Resources Bulletin*, American Water Resources Association, Volume 11, No. 2, April 1975, pg. 358.

3. Michigan Cleaning Agents and Water Conditioners Act, (Act 226, Public Acts of 1971; Effective July 1, 1972) 811:0161.

4. Porcella, Donald B., and A. Bruce Bishop, *Comprehensive Management of Phosphorus Water Pollution*, Ann Arbor Science, Ann Arbor, Michigan, 1975, pg. 186

5. Indiana Phosphate Detergent Law (Indiana Code 1971, 13-1-5.5; Public Law 174, Laws of 1971, Amended by Public Law 97, Laws of 1072, and Public Law 117, Laws of 1973) 471:0141.

6. State of Minnesota, Pollution Control Agency, Chapter Thirty Seven: WPC 37, Standards for the Limitation of the Amount of Phosphorus in Various Cleaning Agents and Chemical Water Conditioners. Section 116 24 (d) Nutrient Limitation.

7. Great Lakes Water Quality Board, International Joint Commission, Great Lakes Water Quality 1975, Appendix C, Remedial Programs Subcommittee Report, pg. 105.

8. Porcella, Donald B., and A. Bruce Bishop, *Comprehensive Management of Phosphorus Water Pollution*, Ann Arbor Science, Ann Arbor, Michigan, 1975, pg. 186.

9 The Canada Water Act; Sections 18 and 19.

STATUS OF PHOSPHORUS REMOVAL FACILITIES IN THE GREAT LAKES

Table 2-5 provides two measures of progress in phosphorus control. The numbers in column A give the proportion of capacity which employed phosphorus removal in 1974. The Agreement pertains to the Lower Lakes (Erie and Ontario): note that most Lake Erie treatment plant capacity has phosphorus removal. The statistics in column B reflects overall phosphorus removal operating efficiencies of these facilities. These percents are based on 1975 data and cannot be compared precisely with the capacity based on 1974 data. However, one would expect in this comparison that the column B percents should exceed or equal column A if phosphorus removal operating efficiency were 100% effective.

Table 2-5+ PERCENT OF DAILY SEWAGE FLOW* FOR WHICH PHOSPHORUS REMOVAL FACILITIES HAVE BEEN PROVIDED AND PERCENT TREATED (SEWAGE FLOW WITH PHOSPHORUS CONCENTRATIONS ≤ 1.0 mg/l)

	United States		Canada		Total	
	% of Facilities with P Removal	Overall Facility Operating Efficiency				
	A	B	A	B	A	B
Lake Superior	4	(5)++	0	(0)++	4	(3)++
Lake Huron	30	(36)	60	(33)	39	(35)
Lake Michigan	89	(42)	--	--	89	(42)
Lake Erie	83	(12)	100	(67)	84	(17)
Lake Ontario & St. Lawrence	20	(5)	84	(22)	54	(15)

+ Modified from Table 10 p. 96 1975 Appendix C Great Lakes Water Quality Board Remdial Programs Subcommittee Report. International Joint Commission.

* Includes all direct dischargers and those indirect dischargers with flow greater than on million gallons a day.

++ Percents computed from Table 5.3 p43, 1976, Appendix C; Great Lakes Water Quality Board Remedial Programs Subcommittee Report; International Joint Commission (Final Draft, May 10, 1977).

The following conclusions are appropriate in light of present knowledge of eutrophication, its causes and prospects for control:**

1. Limiting phosphorus availability in lakes is the single most important and necessary step to be taken now in eutrophication control.
2. The most effective way to do this is to reduce phosphorus inputs.
3. Municipal sewage is the major point source. All such discharges to lakes and other susceptible waters should be treated to reduce phosphorus content to realistic target levels.
4. Phosphorus contributions to sewage should be reduced in every feasible way.
5. Because all inputs are additive, and therefore potentially significant, all should be considered for control.
6. Means must be developed to curtail phosphorus inputs from all significant point and diffuse sources.

**Bartsch A.F., August 1972 "Role of Phosphorus in Eutrophication" EPA-R3-72-001 Ecological Research Series - National Environmental Research Center U.S. EPA, Corvallis, Oregon 97330

Chapter III. Advantages and Disadvantages of a Phosphorus Ban

There are three choices for phosphorus control:

1. Phosphorus can be removed at the treatment plants by chemical precipitation;
2. It can be controlled by limiting its use and subsequent introduction to natural systems; or
3. It can be controlled by the combination of in-plant removal with specific source reductions.

Although in-plant removal is ultimately necessary to achieve the 1.0 mg/l effluent total phosphorus goal, the delay in construction of most treatment facilities makes the third alternative the most appropriate choice now to reduce the phosphorus loading discharged into the receiving waters in a timely fashion. Control of phosphorus in laundry detergents will reduce the influent phosphorus loading to all wastewater treatment facilities by about 40% and effluent phosphorus concentrations by about 50% as discussed in the Appendix to this chapter. The pros and cons of a P-ban in the State of Michigan, Ohio, and Wisconsin and the Great Lakes Basin area are summarized in Tables 3-1, 3-2, 3-3, and 3-4.

Cost and environmental benefits resulting from a P-ban can be estimated based on populations residing in hard water areas and municipal wastewater flows.

The Great Lakes Basin Framework Study showed a total of 6,868,000 Michigan residents served by public water supplies in 1970. The study reported 5,330,900 (78%) were served from Great Lakes sources, 173,200 (2%) served from inland lakes and streams, and 1,364,700 (20%) served from ground water sources. An additional 2,006,300 persons obtained drinking water from private sources.

The State of Ohio Water Plan of Public Water Systems 1969 published by the Ohio Department of Health Division of Engineering Water Supply Unit showed a total of 8,455,178 Ohio residents served by public water supplies in 1969. This report indicated that 6,036,000 persons (71%) were served by surface water supplies and 2,419,178 (29%) were served by ground water supplies. An additional 2,196,839 residents obtained drinking water from private sources. In Ohio's portion of the Great Lakes Drainage Basin, a total of 3,703,600 residents were served by public water supplies in 1970 as reported in the Great Lakes Basin Framework Study Appendix 6. This study reported 2,655,300 persons (72%) were served from Great Lakes sources, 770,400 persons (21%) were served from inland lakes and streams, and 277,900 persons (08%) were served from ground water sources. An additional 676,000 persons obtain drinking water from private sources. In Ohio, the city of Akron's water supply serves 354,900 persons. The city has a P-Ban. The subsequent economic considerations in Ohio from a P-Ban does not include Akron's population.

The State of Wisconsin Public Water Supply Data - 1970 published by Wisconsin Department of Natural Resources' Division of Environmental Protection showed a total of 2,823,000 Wisconsin residents served by public water supplies in 1970. This report indicated that 1,593,000 persons (56%) were served by surface water sources and 1,230,000 persons (44%) were served by ground water sources. An additional 1,594,731 persons obtained drinking water from private sources. In Wisconsin's portion of the Great Lakes Drainage Basin, a total of 1,864,330 residents were served by public water supplies in 1970 as reported in the Great Lakes Basin Framework Study Appendix 6. This study reported 1,325,250 persons (71%) were served from Great Lakes sources, 130,960 persons (07%) were served from inland lakes and stream sources, and 408,120 persons (22%) were served from ground water sources. An additional 752,870 persons obtain drinking water from private sources.

The Great Lakes Basin Framework Study showed a total of 23,693,300 Great Lakes Basin residents served by public water systems. Of these, 17,277,600 persons (73%) receive drinking water from Great Lakes sources, 2,337,600 persons (10%) from inland lakes and streams, and 4,078,100 (17%) from wells. An additional 5,639,000 people receive drinking water from private sources. Most of the private sources of water are obtained from ground water supplies. The area included in the Great Lakes Basin Framework Study is shown in Figure 3-1.

Table 16 of the Great Lakes Water Quality Board 1974 Great Lakes Water Quality Report* indicated that the actual flow of all direct and indirect dischargers with over 1.0 MGD is 3,465 MGD. The total treatment plant flow for plants over 1.0 MGD which discharge into the Great Lakes Drainage Basin are 1,472 MGD for Michigan, 560 MGD for Ohio, and 317 MGD for Wisconsin. Since Akron, Ohio already has a P-Ban, the Lake Erie Basin flow is reduced by 90 MGD to approximate the wastewater flow from Akron. The municipal flow in all of Ohio and Wisconsin for plants over 1 MGD is estimated at 1340 and 520 MGD respectively for 1974.

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*1974 IJC Great Lakes Water Quality Annual Report, Appendix C "Remedial Program Subcommittee Report", pages 66-74.

TABLE 3-1

Summary of Advantages and Disadvantages
of a Phosphate Ban
In the State of Michigan
(Metric Tons)

A. Environmental Benefits

1. Immediate reduction of eutrophication rate of receiving waters.

2. Immediate reduction of sludge generated by 42,700 to 55,100 tons/year.

3. Immediate reduction of total dissolved solids added to receiving waters by 56,900 tons SO a year or 42,100 tons Cl a year

4. Immediate reduction of energy consumption by 2,360,000 to 3,000,000 gallons Number 2 fuel oil a year.

B. Economic Benefits

1. Cost savings for chemicals and sludge disposal of $17,500,000 or more a year, depending on the size of the facilities.

2. Conserve 6,100 tons of phosphorus a year for food production.

3. Conserve 116,000 tons of alum or 63,500 tons of ferric chloride for other industrial uses.

4. Reduce the need for treatment at small plants by reducing influent phosphorous loadings.

C. "Disadvantages" - Alleged Cost to Consumers

a) Procter and Gamble Study in 1975:
Cost to Michigan residents $5,300,000 in 1975.

D. Region V Evaluation

b) Minimum savings from the P-Ban is $12,200,000 a year ($17,500,000 - $5,300,000).

TABLE 3-2

Summary of Advantages and Disadvantages of a Phosphate Ban in the State of Ohio Drainage Basin to Lake Erie
Figures for the entire State within parenthesis
(Metric Tons)

A. Environmental Benefits

1. Immediate reduction of eutrophication rate of receiving waters.
2. Immediate reduction of sludge generated by 12,700 to 17,200 (35,400 to 46,300) tons/year.
3. Immediate reduction of total dissolved solids added to receiving waters by 17,400 (47,500) tons $SO_4^{=}$ a year or 12,900 (35,100) tons Cl a year.
4. Immediate reduction of energy consumption by 720,000 (1,968,000) to 929,000 (2,540,000) gallons number 2 fuel oil a year.

B. Economic Benefits

1. Cost savings for chemicals and sludge disposal of $5,400,000 ($14,800,000) or more a year, depending on the size of the facilities.
2. Conserve 1,870 (5,100) tons of phosphorus a year for food production.
3. Conserve 35,400 (98,000) tons of alum or 19,400 (52,600) tons of ferric chloride for other industrial uses.
4. Reduce the need for treatment at small plants by reducing influent phosphorus loadings.

C. "Disadvantages" - Alleged Cost to Consumers

a) Proctor and Gamble Study in 1975 Cost to Ohio residents of $1,500,000 ($7,200,000).

D. Region V Evaluation

b) Minimum savings from the P-Ban is $3,900,000 ($7,600,000)
$5,400,000 - $1,500,000 ($14,800,000 - $7,200,000).

TABLE 3-3

Summary of Advantages and Disadvantages of a Phosphate Ban in the State of Wisconsin Drainage Basins to Lakes Superior and Michigan
Figures for the entire State within parenthesis
(Metric Tons)

A. Environmental Benefits

1. Immediate reduction of eutrophication rate of receiving waters.
2. Immediate reduction of sludge generated by 9,000 to 12,000 tons/year (15,000 to 20,000 tons/year).
3. Immediate reduction of total dissolved solids added to receiving waters by 12,200 (20,100) tons $SO_4^{=}$ a year or 9,000 (14,900) tons Cl a year.
4. Immediate reduction of energy consumption by 507,000 (834,000) to 655,000 (1,076,000) gallons Number 2 fuel oil a year.

B. Economic Benefits

1. Cost savings for chemicals and sludge disposal of $3,800,000 ($6,300,000) or more a year depending on the size of the facilities.
2. Conserve 1,320 (2,160) tons of phosphorus a year for food production.
3. Conserve 9,000 (15,000) tons of alum or 12,000 (20,000) tons of ferric chloride for other industrial uses.
4. Reduce the need for treatment at small plants by reducing influent phsophorus loadings.

C. "Disadvantages" - Alleged Cost to Consumers

a) Proctor and Gamble Study in 1975
Cost to Wisconsin residents of $1,800,000 ($4,400,000)

D. Region V - Evaluation

1. Minimum savings from the P-Ban is $2,000,000 ($1,900,000)
$3,800,000 - $1,800,000 ($6,300,000 - $4,400,000)

TABLE 3-4

Summary of Advantages and Disadvantages of a Phosphate Ban In the Great Lakes Basin Area (Metric Tons)

A. Environmental Benefits

1. Immediate reduction of eutrophication rate of receiving waters.
2. Immediate reducion of sludge generated by 101,000 to 130,000 tons a year.
3. Immediate reduction of total dissolved solids added to receiving waters by 134,000 ton $SO_4^=$ a year or 99,000 ton Cl^- a year.
4. Immediate reduction of energy consumption by 5,540,000 to 7,160,000 gallon Number 2 fuel oil a year.

B. Economic Benefits

1. Cost savings for chemicals and sludge disposal of $41,500,000 or more a year, depending on the size of the facilities.
2. Conserve 14,400 tons of phosphorus a year for food production.
3. Conserve 275,000 tons alum or 150,000 tons ferric chloride a year for other industrial uses.
4. Reduce the need for treatment at small plants by reducing influent phosphorus loadings.

C. "Disadvantages" - Alleged Cost to Consumers

a) Procter and Gamble Study in 1975.
Cost to the Great Lakes Basin Area residents of $15,200,000 in 1975.

D. Region V Evaluation

b) Minimum savings from the P-ban is $26,300,000 a year ($41,500,000 - $15,200,000).

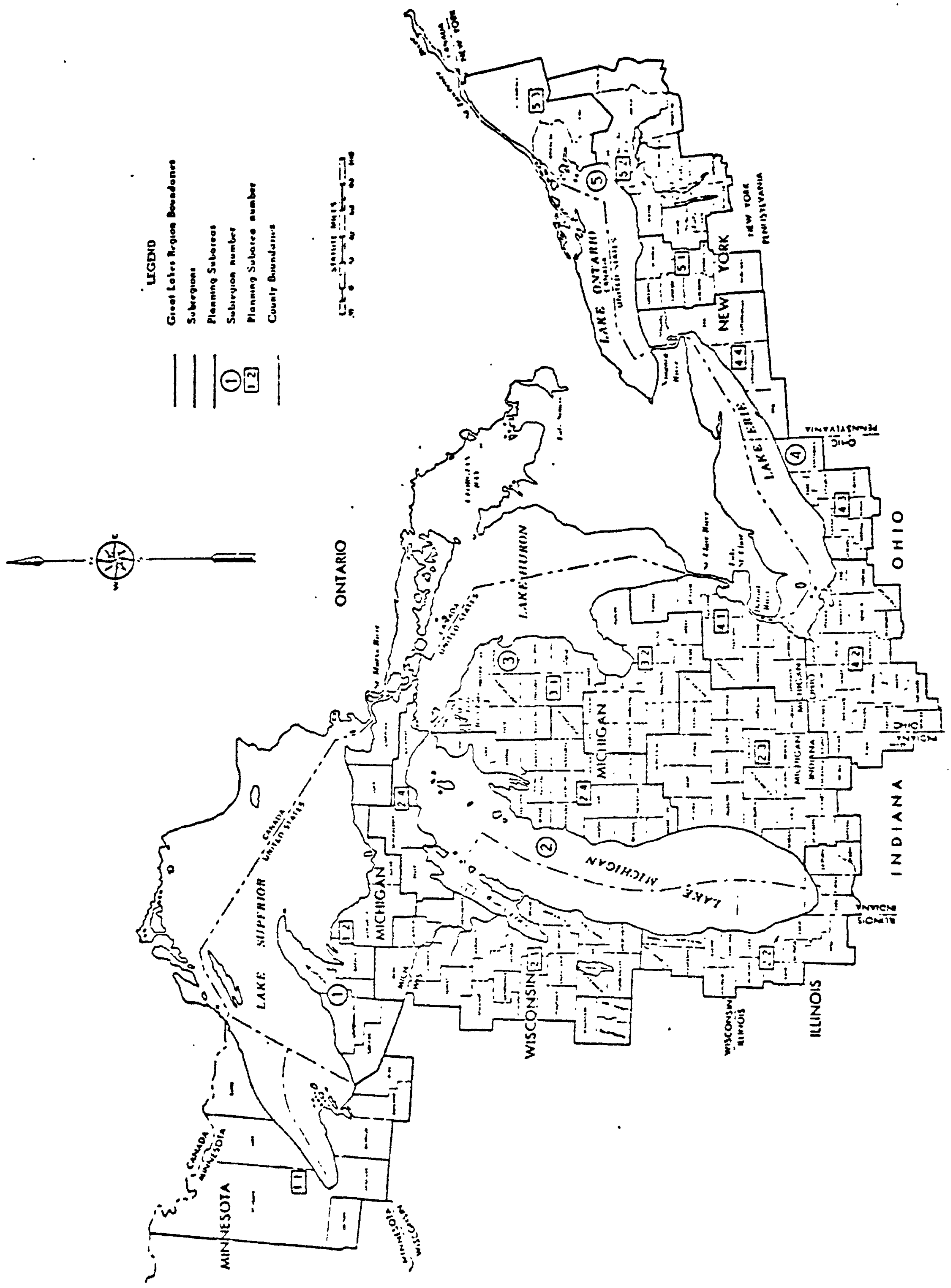

FIGURE 3-1 Great Lakes Region Planning Subareas

The environmental benefits, economic benefits, and disadvantages are discussed based on figures presented in Table 3-1 thru 3-4.

A. Environmental Benefit

A P-Ban would result in an immediate reduction of the eutrophication rate of receiving waters, a reduction of sludge generated and resultant air and land pollution, a reduction of total dissolved solids added to the receiving waters and a reduction of energy consumption.

1. Immediate Reduction of Eutrophication Rate of Receiving Waters

Experience in Indiana and New York indicates that the ambient level of phosphorus in lakes and streams has decreased since the P-Ban went into effect. Also water quality improvements have been recorded. It is, therefore, anticipated that the water quality of both the Great Lakes and inland lakes will be improved through a P-Ban.

a. Great Lakes

Most of the larger wastewater treatment plants in the Great Lakes Basin Area are not achieving the 1 mg/l total phosphorus effluent concentration goal. In some instances it will be five years or more before plants have adequate facilities to precipitate the phosphorus and handle the increased amount of sludge. A P-Ban will complement efforts to remove phosphorus at wastewater treatment plants, although implementation of the P-Ban alone can not meet the 1 mg/l total phosphorus effluent limitation limitation goal. For example, Detroit's current influent and effluent phosphorus loadings are 6,300 tons a year and 4,500 tons a year respectively a removal efficiency of only about 29%. Based on the experience of the Metropolitan Sanitary District of Greater Chicago, it is conservative to estimate that the effluent loading from Detroit would decrease by another 2,000 tons as a result of the P-Ban.

Appendix C of the 1975 Great Lakes Water Quality Annual Report contains a list of plants with their effluent phosphorus concentrations. In the case of Lake Erie, the P-Ban will bring about a reduction of 280 t/a for plants other than Detroit not achieving 1 mg/l. On a Lake Erie wide basis, a 17% reduction could be achieved with the P-Ban with treatment plants remaining at their present levels of removal.

b. Inland Lakes

Potential removal of phosphorus from the P-Ban and estimated phosphorus loadings from detergent in unserviced areas of the Great Lakes area are summarized in Table 3-5 and Table 3-6.

Table 3-5

POTENTIAL REMOVAL OF PHOSPHORUS FROM PHOSPHORUS DETERGENT BAN
Phosphorus Loads Metric Tons

Lake	Detroit STP With Present Treatment (T/Yr)	Other City STP's Not Achieving 1 mg/l (T/Yr)	STP's At 1 mg/l (T/Yr)	Unsewered[3] Population (T/Yr) Min.	Max.	STP's Under[4] 1 MGD (T/Yr)	Sewage[5] Bypasses (T/Yr)	Total Load (T/Yr) Min.	Max.
Superior	-		?	7	60	-	-	7	60
Huron	-		?	36	322	-	-	36	322
Erie	2000[1]	280[2]	?	98	886	278	330	2986	3774
Ontario			PHOSPHORUS DETERGENT BAN IN EFFECT						
Michigan	-	400[2]	?	125	1129	?	350[6]	875	1879

References:

1. P. Pan, EPA, Region V
2. IJC, Water Quality Board 1975 Report, Appendix C . . . WWTT whose effluent yields greater than 1 mg/P/l(loading times .35) lower reduction used in that some of the plants have partial chemical removal.
3. Table 3-6
4. Schuette in Procter and Gamble Letter of 11/10/76
5. EPA, Region V, MODO, R. Buckley Memo
6. Lee, G.F. Phosphorus Water Quality and Eutrophication in Lake Michigan 1972 Conference - Pollution of Lake Michigan and its Tributary Basin, Illinois, Indiana, Wisconsin, Michigan Volume 1 Fourth Session September 19 - 21, 1972 Chicago Illinois.

Prepared by: EPA, Large Lakes Research
Station Grosse Ile, Michigan
December 1976

Table 3-6

ESTIMATED PHOSPHORUS LOADINGS FROM DETERGENTS IN UNSEWERED AREAS OF THE GREAT LAKES

Lake	Unsewered Population	Minimum[5] Per Capita Load Potential Kg P.Capital/Yr	Minimum Total Load (Metric T/Yr)	Maximum[5] Per Capita Load Potential Kg P/Capita/Yr	Maximum[6] Total Load (Metric T/Yr)
Superior	118,100[1]	.057	7	.513	60
Huron	627,800[2]	.057	36	.513	322
Erie	1,727,000[3]	.057	98	.513	885
Ontario	657,000[4]	PHOSPHORUS DETERGENT BAN IN EFFECT			
Michigan	2,200,000[7]	.057	125	.513	1129

References:

1. IJC, Upper Lakes Reference Report, Vol. 1
2. IJC, Upper Lakes Reference Report, Vol. 1
3. Schuette in Proctor and Gamble Letter of 11/10/76
4. Schuette in Proctor and Gamble Letter of 11/10/76
5. Schuette in Proctor and Gamble Letter of 11/10/76 (.57 Kg P/Cap/Yr)
   Dillon and Viraraghavan (10% retention of Phosphorus by drain fields)
6. By computation
7. Great Lakes Basin Framework Study - Report Table 8 p. 32
   and Appendix 19 Economic and Demographic Studies Table 19-2 p.3

Studies conducted by the State of Indiana have demonstrated positive effects by reducing phosphorus concentration in Indiana lakes and reservoirs. Two lakes and one reservoir were chosen for a comparison of before-and-after studies. These include the Mississinewa Reservoir which drains a large area containing many sewage treatment plants; Long Lake which receives the effluent from the Angola Sewage Treatment Plant, as well as septic tank effluent from the Town of Pleasant Lake and a few shoreside cottages; and Olin Lake which is largely undeveloped and receives only a small amount of agricultural runoff. Table 3-7 is a summary of the results for the comparative studies.

TABLE 3-7

SUMMARY OF INDIANA COMPARATIVE STUDIES
TOTAL PHOSPHORUS (mg/l)

Olin Lake

Station	State Survey	N.E.S. Survey	Percent Change
	July 26, 1972	August 6, 1973	
Center	.01 mg/l	.011 mg/l	0

Mississinewa Reservoir

Station	State Survey	N.E.S. Survey	State Survey	Percent Change
Just east of S.R. 13	August 2, 1972 .217 mg/l	August 3, 1973 .161 mg/l	August 7, 1975 -	-26%
Just east of Red Bridge	.108 mg/l	.093 mg/l	-	-14%
Near Dam	.075 mg/l	.046 mg/l	.02	-73%

Long Lake

Station	State Survey	N.E.S. Survey	State Survey	Percent Change
	August 27, 1970	August 6, 1973	July 30, 1975	
Center of Main Basin	1.2 mg/l	0.38 mg/l	.12	-90%

Surveys conducted as part of the State's Lake Studies Program indicate that significant phosphorus reductions have occurred in a number of other lakes and reservoirs.

In the State of Michigan over 90% of its more than 2,000 lakes are not sewered. Approximately 40% of these lakes show enrichment problems due in part to shoreline development. A P-Ban will reduce the amount of phosphorus entering the lakes from septic tank drain fields by about 33%.

In addition, many small communities use stabilization lagoons to treat the wastewater. While these lagoons achieve minimal phosphorus removal, it is difficult to reduce this further by addition of phosphorus removal facilities to a pond. A P-Ban will provide a benefit similar to that for septic tank drain fields.

2. Immediate Reduction of Sludge Generated and Resultant Air and Land Pollution

Removing phosphorus by chemical precipitation generates excess sludge from 20% (using alum or ferric chloride) up to 200% (using lime) of the total sludge produced in conventional secondary treatment plants. The amount of sludge generated depends mainly on the phosphorus content, the chemicals used, the alkalinity and the pH of the wastewater to be treated. Based on a 3.0 mg/l reduction of influent phosphorus concentration, a P-Ban will reduce the sludge generated as folows in the State of Michigan ranging from 42,700 tons/year (using alum) to 55,100 tons/year (using ferric chloride), in the Great Lakes Basin of Ohio ranging from 12,700 tons/year (using alum) to 17,200 tons/year (using ferric chloride), and in the Great Lakes Basin of Wisconsin ranging from 9,000 tons/year (using alum) to 12,000 tons/year (using ferric chloride). For the Great Lakes Basin Area production of sludge will be reduced 101,000 tons/year (using alum) to 130,000 tons/year (using ferric chloride).

National air pollution standards for emissions from municipal sludge incinerators limit emissions for particulates from incinerators used to burn wastewater sludge to "No more than 0.65 g/kg dry sludge input (1.30 lb./ton dry sludge input)". Assuming that 10%* of the treatment facilities use incineration and that all are meeting the "New Source Standards", a 3.0 mg/l reduction of influent phosphorus means a reduction of approximately 7,000 lbs. of particulate emissions a year in the State of Michigan, approximately 2,100 lbs. of particulate emissions a year in the Great Lakes Basin of Ohio, approximately 1,500 lbs. of particulate emissions a year in the Great Lakes Basin of Wisconsin and approximately 16,500 lbs. of particulate emissions a year in the entire Great Lakes Basin.

The Metropolitan Sanitary District of Greater Chicago (MSDGC) has been shipping its wet sludge to Fulton County, Illinois (180 miles away from Cook County) for the reclamation of strip-mined land. There does not appear to be a saturation period after eleven years of application. Problems with PCB's and heavy metals have not occurred in crops grown on the land.**

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* Association of Metropolitan Sewage Agencies (AMSA), "Field Report on Current Practices and Problems of Sludge Management"

** Dr. David Zenz, Coordinator of Research, Research & Development - Metropolitan Sanitary District of Greater Chicago, Personal Communication (April 1977)

Based on MSDGC's estimation, in the first year 75 dry tons/acre can be applied safely, with the amount tapering down to 20 dry tons/year/acre in five years. Application rates are lower on undisturbed soils. The application rate of 20 to 30 dry tons/acre/year can be maintained. The reduction in land requirement for wet sludge disposal resulting from a P-ban (90% of the total sludge generated) would then be approximately 2000 acres for Michigan, 600 acres for Ohio, and 400 acres for Wisconsin when restricted to the Great Lakes Drainage Basin with a total of 4600 acres for the entire basin.

3. Immediate Reduction of Total Dissolved Solids Added to Receiving Waters

The total dissolved solids content in drinking water should preferably not exceed 250 parts per million (ppm).* The allowable total dissolved solids content for modern ultrahigh pressure steam power plants is less than 1.0 ppm. The specific objective of the International Joint Commission Agreement, Annex 1, Specific Water Quality Objectives, requires that the level of total dissolved solids should not exceed 200 mg/l or the present (1972) levels.

Chemical precipitation for phosphorus removal adds extraneous ions to the treated effluent, which in turn adds total dissolved solids to the receiving waters. Each pound of alum used as aluminium will generate 5.35 pounds sulfate ion (SO) and each pound of ferric chloride used as iron will generate 1.91 pounds chloride ion (Cl). Based on a 3.0 mg/l reduction of influent phosphorus, an immediate reduction of total dissolved solids added to the receiving waters would be 56,900 tons sulfate ion per year or 42,100 tons chloride ion per year for the State of Michigan and 17,400 tons sulfate ion per year or 12,900 tons chloride ion per year for the Great Lakes Basin portion of Ohio, 12,200 tons sulfate ion per year or 9,000 tons chloride ion per year for the Great Lakes Basin portion of Wisconsin, and 134,000 tons sulfate ion per year or 99,000 tons chloride ion per year for the entire Great Lakes Basin.

4. Immediate Reduction of Energy Consumption

Sludge incineration is an energy consuming process. Fifty gallons of number two fuel oil are required to burn a ton of sludge.** Based on a 3.0 mg/l reduction of influent phosphorus concentration, a reduction of energy consumption for burning chemical sludge alone would range from 2,360,000 to 3,040,000 gallons of number two fuel oil a year for the State of Michigan, from 720,000 to 929,000 gallons of number two fuel oil for the Great Lakes Basin drainage area of Ohio, from 507,000 to 655,000 gallons of number two fuel oil a year for the Great Lakes Basin drainage area of Wisconsin or a total of 5,540,00 to 7,160,000 gallons of number two fuel oil for the entire Great Lakes Basin.

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* Op Cit. 1976 Quality Criteria For Water, p394.

**Olexsey, R. and J.B. Farrell, "Sludge Incineration and Fuel Conservation," "News of Environmental Research in Cincinnati," U.S. EPA, May 3, 1974.

B. Economic Benefits of a Phosphorus Ban

Another beneficial effect of a P-Ban is the cost saving due to the reduction of chemicals needed for phosphorus removal, equipment to handle the chemical sludge generated, and its ultimate disposal. In addition to this cost saving, a P-Ban also conserves phosphorus for food production, conserves chemicals for other industrial use, and reduces the required treatment at small plants.

1. Cost Saving for Chemicals and Sludge Disposal

Dr. Edwin Barth, of the Environmental Protection Agency, Cincinnati Laboratory, estimates that with a one-third reduction in phosphorus concentration, excluding the cost reduction for sludge handling, chemical and operating costs might be reduced about 20 percent.

The Michigan Department of Natural Resources (MDNR) staff reported that the average chemical and sludge handling costs, excluding the cost for ultimate sludge disposal, is $3.45 per capita per year for six municipal wastewater treatment facilities in Michigan. The current flows of these facilities range from 0.87 MGD to 17.5 MGD, with an average flow of 6.2 MGD.

The Region V staff estimates that a cost saving of $1.20 per capita per year will result from a P-Ban for treatment facilities with a flow greater than 100 MGD. This estimate is based on (1) a water consumption rate of 100 gallons per capita per day; (2) a 3.0 mg/l influent phosphorus concentration reduction resulting from a P-Ban; (3) October 1976 chemical costs; and (4) MSDGC cost analysis for sludge handling and ultimate disposal.

Based on our earlier discussion, the reductions in cost resulting from a P-Ban within the Great Lakes Drainage Basin are $17.5 million per year for the State of Michigan, $5,400,000 million per year for Ohio, (excluding Akron, Ohio) $3,800,000 million per year for Wisconsin and a total of $41.5 million per year for the entire Great Lakes Basin. For smaller facilities, which have not been included, we would expect greater cost reductions.

2. Conserving Phosphorus for Food Production

Based on a 3.0 mg/l total phosphorus reduction in wastewater influent due to a P-Ban, we calculated that 6,100 tons/year of phosphorus in Michigan, 1,870 tons/year of phosphorus in Ohio, 1,320 tons/year of phosphorus in Wisconsin, and a total of 14,400 tons/year of phosphorus in the entire Great Lakes Basin can be conserved for food production.

3. Conserving Chemicals for Other Industrial Use

Based on a 3.0 mg/l total phsophorus reduction in wastewater influent, it can be calculated that 116,000 tons of alum or 63,500 tons of ferric chloride in the State of Michigan, 35,400 tons of alum or 19,400 tons of ferric chloride in Ohio's Great Lakes Drainage Basin, 9,000 tons of alum or 12,000 tons of ferric chloride in Wisconsin Great Lakes Drainage Basin or 275,000 tons of alum or 150,000 tons of ferric chloride can be conserved in the entire Great Lakes Basin.

4. Reduction of Required Treatment at Small Plants

In the many small communities using septic tanks and wastewater treatment lagoons, where phosphorus removal efficiency is minimal, a P-Ban will reduce their phosphorus loading by approximately 33%. Although the P-Ban alone may not allow them to achieve the 1 mg/l total phosphorus effluent level, the P-Ban will at least reduce their receiving waters' rate of eutrophication.

C. "Disadvantages" - Alleged Cost to Consumers

Two studies financed by detergent and related industries which were made available to Region V have reported that a P-Ban may result in "cost penalties" to consumers. These "penalties" are claimed to be $23.27 per family per year by Homemaker Testing Corporation (HTC) in 1974 and $5.17 by the Procter and Gamble Company (P&GC) in 1975. Region V considers the HTC report to be invalid and misleading, as discussed in Section 111-C-3. The $5.17 "cost penalty" claimed by the P&GC report is used for discussion, though this study is also biased in our opinion.

Both reports made invalid comparisons by selecting the "banned area" with poorer water quality than the "un-banned area(s)" under study. Despite the fact that this cost differential may have resulted from the difference in water quality, the "cost penalties" of $23.27 in 1974 and $5.17 in 1975 seems to indicate that this cost differential is rapidly diminishing and may even favor non-phosphorus detergent in the future. When all influential factors are taken into consideration, the cost differential favors the non-phosphate detergents.

As will be discussed in Chapter IV, adverse effects of non-phosphorus detergents, to the extent they exist, are associated with hard water. Water containing more than 150 mg/l is assumed to be hard for our cost estimates. The majority of Michigan and Great Lakes Basin Area residents are served from the Great Lakes and inland surface waters. The water supplied from these sources has a total hardness of less than 150 mg/l. Only 38% and 33% of the residents in Michigan and the Great Lakes Basin Area, respectively obtain drinking water from ground water sources and/or private sources that may have a total hardness higher than 150 mg/l. In Ohio (43%) and Wisconsin (64%) of the residents in these States obtain their drinking water from ground water sources and/or private sources that may have a total hardness higher than 150 mg/l. In the Great Lakes Drainage Basins' of Ohio and Wisconsin respectively, 22% and 44% of the residents obtain their drinking water from sources which may have a total hardness higher than 150 mg/l. Assuming the $5.17 per household (3.3 persons) per year additional cost to be fact, only residents using "hard water" would probably be affected by the full $5.17 in 1975. Based on these figures, the costs for the entire States of Michigan, Ohio, and Wisconsin would be estimated at $5.3, $7.2, and $4.4 million respectively, according to P & G Company. Within the entire Great Lakes Drainage Basin and the portions of each State within this hydrologic boundary, the costs would be estimated at $15.2 (Great Lakes Basin), $5.3 (Michigan), $1.5 (Wisconsin), and $1.8 (Ohio) millions.

1. The Homemaker Testing Corporation (HTC) Report of 1974

The HTC prepared a report for the FMC Corporation in 1974 to compare non-phosphate detergent use in Indianapolis, Indiana, where there is a ban, and phosphate detergent use in Kansas City, Kansas. This study selected 200 families in each city. None of the families had a home water softener. The report concluded that a "cost penalty" of $23.27 per family per year has resulted from the use of non-phosphate made detergent. These costs resulted from the use of additional detergent, more laundry additives, rewashing and rerinsing clothes.

2. The Procter and Gamble Company Study of 1975

A letter from Mr. J.W. Schuette of P&GC to Mr. S. T. Davis of the U.S. Environmental Protection Agency, Washington, D.C., made the following statement:

> "During 1975, P&GC developed additional information based on market sales data comparing Indianapolis (zero phosphate area) with the demographically similar cities of Cincinnati, Dayton, and Columbus (phosphate areas). These studies indicated an added annual cost per household of $4.17 in the zero phosphate area due to increased use of detergents, laundry aids and performance boosters. The $4.17 figure is averaged over all Indiana households, and is probably very conservative. This is because it is based on actual sales figures, even though we know that some Indiana consumers have either purchased permanent home water softeners or have purchased their detergent outside of Indiana to relieve some of the performance negatives of the non-phosphate granular detergents."
>
> "Other areas where the current carbonate-base, non-phosphate detergents can cause additional consumer costs are increased machine repairs, increased garment wear-out due to poor cleaning and carbonate deposition, and installation and operation of permanent home water softeners. At this point, we would estimate the cost of increased machines repair to be approximately $1.00 per household per year, based on service call records of a major applicance manufacturer. Garment wear-out and home water softener costs have been difficult to quantify accurately. To be conservative, we therefore estimate that a ban will cost the average household a minimum of $5.17 per year, based on available data."

3. Region V's Evaluation

Both of the above-mentioned studies ignored the most important factors -- water supply characteristics -- which would affect the dosage of detergent and chemical additives needed per wash load, which in turn affect the cost per wash load.

The HTC Report compares Indianapolis, Indiana, with Kansas City, Kansas. The P&GC study compares the State of Indiana, based on market sales data, with three cities: Cincinnati, Columbus and Dayton in Ohio.

The water supply characteristics for the study year of the key cities under study are tabulated in Tables 3-8 and 3-9. Specific quantitative information regarding the water supply characteristics for the State of Indiana are not available to Region V at this time. In general, the total hardness of the water supplies for the State of Indiana is in the range of 300 - 400 mg/1. Only 14 or 15 of the 455 water supply utilities in the State of Indiana treat their water with a lime-soda softening process. For the purpose of comparison, the water supply of Indianapolis is chosen as representative of the water supply of the State.

TABLE 3-8

Water Supply Characteristics
of
Indianapolis, Indiana and Kansas City, Kansas

Annual Average 1974

	Indianapolis, Indiana	Kansas City, Kansas
Total Hardness in mg/1	261	219
Iron in ppb as Fe	30	4
Manganese in ppb as Mn	10	less than detectable limit
pH ranges	6.70 - 8.11	7.5 - 8.4
Color	10	1

TABLE 3-9

Water Supply Characteristics
of
Indianapolis, Indiana,
Cincinnati, Ohio, Dayton, Ohio and Columbus, Ohio

Annual Average, 1975

	Indianapolis	Cincinnati	Columbus	Dayton
Total Hardness in mg/l	251	146	126	154
Iron in ppb as Fe	30	0.02	0	0
Manganese in ppb as Mn	0	0	0	0
pH range	6.9 - 8.0	8.4	8.6 - 8.7	9.6 - 10.0
Color	10	1 or 2	0	0

a. Total Hardness of Water Supplies.

As illustrated in Tables 3-10 through 3-12 Washability Performance for both "Low Phosphate" and "No Phosphate" detergents are strongly dependent upon the total hardness of the water used. The total hardness of water supplies for Indianapolis, Indiana, and Kansas City, Kansas, during the study in September and October 1974 happened to be very similar. However, the 1974 annual average data for Indianapolis' total hardness was 42 mg/l higher than Kansas City, Kansas. The maximum total hardness for the State of Indiana in 1974 was as high as 344 mg/l. Those "hard" days may have caused the needed additional detergent, more laundry additives, rewashing and rerinsing as reported by HTC.

The annual average total hardness of Indianapolis in 1975 was 251 mg/l, whereas all the water utilities for Cincinnati, Columbus, and Dayton in Ohio supply relatively soft water (average total hardness for the study year ranges from 126 to 154 mg/l).

Based on the above, it can be concluded that a substantial fraction of HTC's $23.27 in 1974 and P&GC's $5.17 in 1975 cost differentials are attributable to the differential in total hardness of the water supplied to these cities under study.

TABLE 3-10

WASHABILITY PERFORMANCE*

RELATIVE SOIL REMOVAL OF LOW AND NONPHOSPHATE DETERGENT

WATER HARDNESS EFFECTS/0.20% CONCENTRATION

Water Hardness	Cotton		Polyester	
	Low P	Non P	Low P	Non P
150 ppm	90.0%	77.2%	92.4%	66.5%
300 ppm	75.3%	77.8%	72.4%	66.6%

MRC - Manufacturer's recommended concentraiton, average is 0.13%

Water Hardness -- As CaCo, 150 ppm = 8.8 gpg
300 ppm = 17.5 gpg

Data -- Average soil removal data for top selling major brand detergents (60% of retail market).

b. Suyrvey Population

(i) The HTC report completely omitted from the survey population households with home water softeners. In Indianapolis, this amounted to the elimination of 1 of every 3 households from the survey.

(ii) The HTC report failed to compare the age groups of children, particularly the age groups under 3 and around 6. For children under 3, a lot of bleach and softener would be needed for cleaning diapers. Children at around the age of 6 always have dirtier clothes to be cleaned.

(iii) The HTC report failed to compare the professions of the adults. For example, an auto machanic may be in the same income bracket as a college professor, but an auto mechanic needs a lot more spotter to clean his clothes than a office worker.

(iv) The P & GC study compares urban residence (three big cities of Ohio) and a general population, including both urban and rural residents.

*Rutkowski, B.J. "Performance Characteristics of Non-Phosphate Detergents" Science Research Department Whirlpool Corporation Benton Harbor, Michigan, presented at Michigan Natural Resources Commission meeting December 8, 1976.

TABLE 3-11

RELATIVE PERFORMANCE OF 8.7% PHOSPHORUS DETERGENTS COMPARED TO SEARS NON-PHOSPHATE DETERGENT % ALL PRODUCTS TESTED AT EQUAL CONCENTRATION

Brand—Cloth—Hardness		Relative Performance (120°F) Soil Removal	Whiteness Retention	Brightener Pickup	Overall Rating
SEARS NON-PHOSPHATE					
Cotton	140 ppm	100.0	100.0	100.0	100.0
	300 ppm	100.0	100.0	100.0	100.0
Polyester	140 ppm	100.0	100.0	100.0	100.0
	300 ppm	100.0	100.0	100.0	100.0
Average		100.0	100.0	100.0	100.0
BOLD					
Cotton	140 ppm	97.7	95.6	101.8	98.4
	300 ppm	77.5	94.0	100.4	90.6
Polyester	140 ppm	92.2	85.1	100.6	92.6
	300 ppm	50.8	71.2	99.2	73.7
Average		79.6	86.5	100.5	88.8
CHEER					
Cotton	140 ppm	92.9	86.9	98.0	92.6
	300 ppm	73.5	91.3	101.7	88.8
Polyester	140 ppm	99.8	90.6	100.5	97.0
	300 ppm	69.1	91.5	101.0	87.2
Average		83.8	90.1	100.3	91.4
GAIN					
Cotton	140 ppm	86.5	80.1	95.2	87.3
	300 ppm	74.3	84.5	97.9	85.6
Polyester	140 ppm	88.6	78.6	100.3	89.2
	300 ppm	56.0	82.6	99.8	79.5
Average		76.4	81.5	98.3	85.4
TIDE					
Cotton	140 ppm	88.4	86.1	98.2	90.9
	300 ppm	76.5	89.9	99.4	88.6
Polyester	140 ppm	95.1	90.4	100.6	95.4
	300 ppm	55.4	85.6	100.3	80.4
Average		78.9	88.0	99.6	88.8
ALL					
Cotton	140 ppm	92.2	99.4	94.7	95.4
	300 ppm	75.0	99.2	92.8	89.0
Polyester	140 ppm	92.8	94.5	101.7	96.3
	300 ppm	56.9	69.9	99.5	75.4
Average		79.2	90.8	97.2	89.0
DRIVE					
Cotton	140 ppm	95.4	93.9	90.6	93.3
	300 ppm	81.4	92.0	89.3	87.6
Polyester	140 ppm	89.2	79.6	101.0	89.9
	300 ppm	66.0	75.4	100.0	80.5
Average		83.0	85.2	95.2	87.8
AJAX					
Cotton	140 ppm	92.5	99.1	103.8	98.5
	300 ppm	76.4	102.6	104.0	94.3
Polyester	140 ppm	89.4	82.0	103.5	91.8
	300 ppm	51.9	81.0	102.6	78.5
Average		77.7	91.2	103.5	90.8
COLD POWER					
Cotton	140 ppm	95.7	94.8	102.8	97.8
	300 ppm	74.0	98.9	103.2	92.0
Polyester	140 ppm	99.7	79.0	104.0	94.2
	300 ppm	49.2	73.3	103.9	75.5
Average		79.7	86.5	103.5	89.9
FAB					
Cotton	140 ppm	92.7	90.4	100.9	94.7
	300 ppm	75.7	92.4	101.6	89.9
Polyester	140 ppm	98.5	88.6	102.6	96.6
	300 ppm	62.4	89.0	102.6	84.7
Average		82.3	90.1	102.0	91.5
PUNCH					
Cotton	140 ppm	96.2	99.2	102.9	99.4
	300 ppm	86.5	104.6	105.1	98.7
Polyester	140 ppm	90.3	81.6	100.5	90.8
	300 ppm	53.1	73.7	99.7	75.5
Average		81.5	89.8	102.1	91.1

*Howe, R. S., Morris, J. G. and Poston, H. W. "Laundry Detergents and Environmental Quality" School of Public and Environmental Affairs, Indiana University. Occasional Papers No. 2, May 1973

TABLE 3-12

DETERGENCY OF VARIOUS DETERGENTS AT DIFFERENT WATER HARDNESS*

Water Hardness (ppm)	Detergent	Percent Soil Removal Empa 101	U.S. Testing	TFI 65/35 PE/C P.P.	TFI Cotton	4 Test Cloth Avg.
0	Nonionic Carbonate	61.6	24.2	39.6	30.0	38.9
0	Anionic Phosphate	59.0	19.8	38.2	38.8	39.0
0	Nonionic Phosphate	51.2	17.7	27.1	27.8	31.0
20	Nonionic Carbonate	57.1	19.4	32.0	30.2	34.7
20	Anionic Phosphate	58.4	19.2	35.6	36.8	37.5
20	Nonionic Phosphate	50.1	17.4	25.6	19.2	28.1
50	Nonionic Carbonate	63.6	21.4	38.5	32.7	39.0
50	Anionic Phosphate	54.6	18.1	34.7	36.4	36.0
50	Nonionic Phosphate	49.4	16.8	23.5	24.4	28.5
150	Nonionic Carbonate	61.1	20.3	35.6	29.7	36.7
150	Anionic Phosphate	51.3	17.0	34.6	34.5	34.4
150	Nonionic Phosphate	43.3	11.9	20.6	16.7	23.1
300	Nonionic Carbonate	56.8	17.7	33.5	29.5	34.4
300	Anionic Phosphate	41.2	19.3	37.1	28.8	31.6
300	Nonionic Phosphate	25.6	11.4	19.6	16.7	17.3

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*Howe, R. S. Morris, J. G. and Poston, H. W. "Laundry Detergents and Environmental Quality" School of Public and Environmental Affairs, Indiana University Occasional Papers No. 2, May 1973.

c. Bleach

The amount of bleach needed depends mainly on the iron and manganese content and color of the water supply. Iron and manganese causes stain, "red water" scale, and black spot. As illustrated in Tables 3-8 through 3-9, respectively, the iron concentration in Indianapolis is approximately 10 to 20 times as high as all the other cities under study. The maximum manganese concentrations in Indianapolis are as high as 30 ppb whereas in the other cities, the manganese is at the less than detectable limit. As to color units, in Indianapolis on the average it is ten times that of the other cities. All the above would result in using substantially more bleach in Indianapolis than in the other cities. In addition fabric strength loss increases when excess amounts of bleach are used. A large excess of bleaching may also result in bad soil removal efficiency, which in turn results in more detergent consumption.

d. pH

A pH below 8.0 in relatively soft water will cause corrosion of the water pipe. A pH below 7.0 may impair the effectiveness of a sequestering agent which forms soluble complexes with calcium and magnesium, instead of insoluble precipitants. As illustrated in Tables 3-8 and 3-9 from 1974 through 1975, the minimum pH in Indianapolis dropped below 7.0, whereas in all the other cities, the pH is always above 7.0. In addition, fabric strength loss decreases when the pH of the bleach bath is increased.

e. Size of Washload

The HTC report failed to consider the size of the washload. For example, top loading automatic washers require twice as much detergent as front loading automatic washers per wash.

f. Hardness

The property of hardness in water is due principally to the presence of carbonates, bicarbonates, sulfate or other compounds of calcium and magnesium. Water hardness diminishes the ability of soap or detergents to form suds and the carbonate hardness forms a scale deposited on the inside surfaces of boilers and water heaters, making them less efficient and necessarily requiring frequent cleaning or replacement. The standard for permissible hardness varies from less than 50 mg/l to 150 mg/l. Experience has shown that hardness in excess of 200 mg/l may cause some problems in the household. Even without adding any precipitant, calcium and/or magnesium scale tend to form and to cause more frequent washer repair services in hard water areas.

g. Summary

It is significant to note that the largest share of the estimated increase in cost was due to the use of laundry aids and additives which would be expected to do little or no good in improving performance. The occasional double wash or rinse in the cities may have resulted from abnormally high total hardness of the water from the tap during the washing period. Thus, consumer education on correct laundry practices and use of water softeners in those areas which have excessive hard water, would seem appropriate.

It is our estimation that, to remove each grain (17.14 mg) of hardness in raw water using home water softeners, the cost saving on detergent is $2.60 per family per year. The annual amortized cost for softeners is about $30 per year. Based on these estimations, the break even point for installing water softeners is about 200 mg/l total hardness. In addition to the cost saving in detergent, water softening would prevent scale formation in the water supply pipes and in the hot water heater. It would prolong the life of the water pipe and hot water heater, and improve the efficiency of the hot water heater, which in turn conserves energy.

Excluding all the other influential factors, the minimum cost benefits resulting from a P-Ban can be obtained by subtracting the cost to consumers due to the cost differential claimed by P&GC ($5.17/per capital/ year) from the cost savings on chemicals and sludge disposal which results from a P-ban. These minimum net cost benefits per year are estimated for the residents of the following areas at $12.2 million (State of Michigan), $3.9 million (within the Great Lakes Drainage Basin of Ohio (excluding Akron), $2.0 million (within the Great Lakes Drainage Basin of Wisconsin), and $26.3 million savings (entire Great Lakes Basin Area). The minimum net cost benefits per year for the entire states of Ohio and Wisconsin are estimated at $7.6 and $1.9 million respectively.

Appendix Impact of P-Ban Phosphorus in Wastewater

In areas where a ban on phosphates has been implemented, measurable decreases in the concentrations of phosphorus in sewage have been reported within months of implementation. Measurable decreases in total and the phosphate in receiving streams were observed within a year. Thus, dual benefits of conservation of resources while also reducing expenditures of both energy and capital for wastewater treatment facilities are achieved.

The following studies* show that the reduction of phosphorus content in detergent has resulted in a significantly lower phosphorus influent as well as effluent phosphorus concentration in sewage.

1. During an evaluation of a demonstration pressure sewer system in New York State serving a small group of single family homes, the phosphorus concentration in the domestic wastewater was determined during separate 3-week time periods when phosphorus detergents and non-phosphate, heavy duty soap were used. A phosphorus reduction of 48 percent was observed during this study. Monthly data collected pre- and post-ban from one Monroe County New York facility indicated a 55 percent phosphorus reduction from 1973 to 1975.

2. A review of available phosphorus data from municipal discharges in the New York portion of the Great Lakes Basin has been undertaken to evaluate the effectiveness of the phosphorus-in-detergent ban. The majority of these dischargers are in Erie County where a county-wide ban preceded the statewide ban by 1-1/2 years. The statewide ban, which became effective on June 1, 1973, limited phosphorus to 0.5 percent by weight of the product content. Influent and effluent samples have been collected at most municipal facilities at least once a year in connection with New York's operation and maintenance inspection program. This annual data was evaluated for discrete

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*1975 IJC Great Lakes Water Quality Board, Great Lakes Water Quality Appendix C. Remedial Program Subcommittee Report pp. 104-107.

time periods in order to determine the trend in municipal phosphorus concentrations. Figure A-1 shows a reduction in influent phosphorus concentrations of 53 percent from 1972 to 1975.

3. From 1971 through 1975 Indiana Stream Pollution Control Board's staff conducted a large number of 29 hour surveys of municipal wastewater treatment plants. As illustrated in Figure A-2*, the influent concentration of total phosphorus has dropped from about 12 mg/l prior to the P-Ban down to about 4.5 mg/l after the P-Ban.

4. The Metropolitan Sanitary District of Greater Chicago (MSDGC)'s report examined the phosphorus concentrations and other data for the raw sewage and the effluents from the three major treatment works of the Metropolitan Sanitary District of Greater Chicago prior to and after the ordinance banned phosphorus-containing detergents went into effect, on June 30, 1972.

   The Metropolitan Sanitary District serves an area of approximately 860 square miles including the City of Chicago and over 110 surrounding communities. The District maintains and operates three major treatment works, North Side, West-Southwest and Calument, all of which receive a part of the wastewaters treated from the City of Chicago.

   The annual average concentrations of phosphorus found in the influent sewages have shown a decrease in 1972 as compared to previous years are summarized in Table A-1. The raw sewage phosphorus concentration at the North Side STW has decreased from an annual average of 10 mg/l P for the 1969-1971 period to an annual average of 4.9 mg/l P in 1972. The degree of reduction was not as great at the Calumet STW where the annual average phosphorus concentration was 9.2 mg/l P for 1969-1971 and 7.9 mg/l P in 1972.

   A more noticeable decline in phosphorus levels has been observed in the final effluents from the three major treatment works. The reduction in the raw sewage phosphorus levels at Calumet and North Side appears to be directly related to the reduction in phosphorus containing detergents in those segments of the two service areas in which the phosphorus ban is effective; i.e., those segments which lie within the corporate limits of the city of Chicago. Dr. Cecil Lue-Hing** did not know of any other factors which may have occurred which would effect such a reduction. Factors, such as storm flows, which would affect the phosphorus concentrations, while variable did not appear to be appreciably different in those years. The final effluent concentrations of phosphorus at North Side STW were lower in 1972 (yearly average of 3.1 mg/l P) than in the period of 1969-1970 (yearly averages of 5.2 and 6.1 mg/l P). At the Calumet STW, the final effluent concentrations decreased from a level of 4.9 mg/l P during the 1969 - 1971 period to 2.8 mg/l P in 1972.

   The final effluent concentrations for the West-Southwest STW averaged 2.5 mg/l for the 1969-1971 period as compared to 1.3 mg/l P in 1972. However, in the case of the Southwest raw sewage, the complexity

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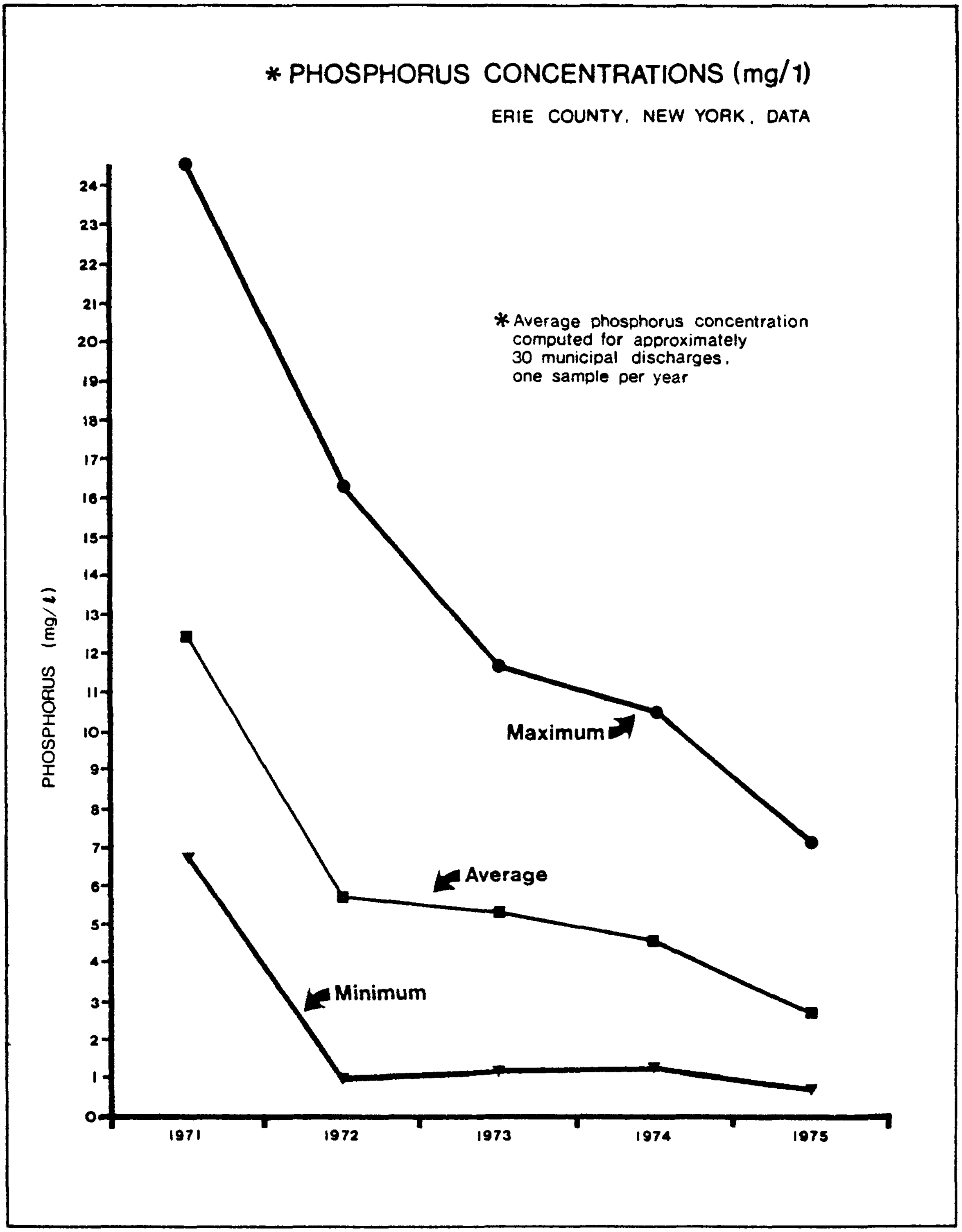
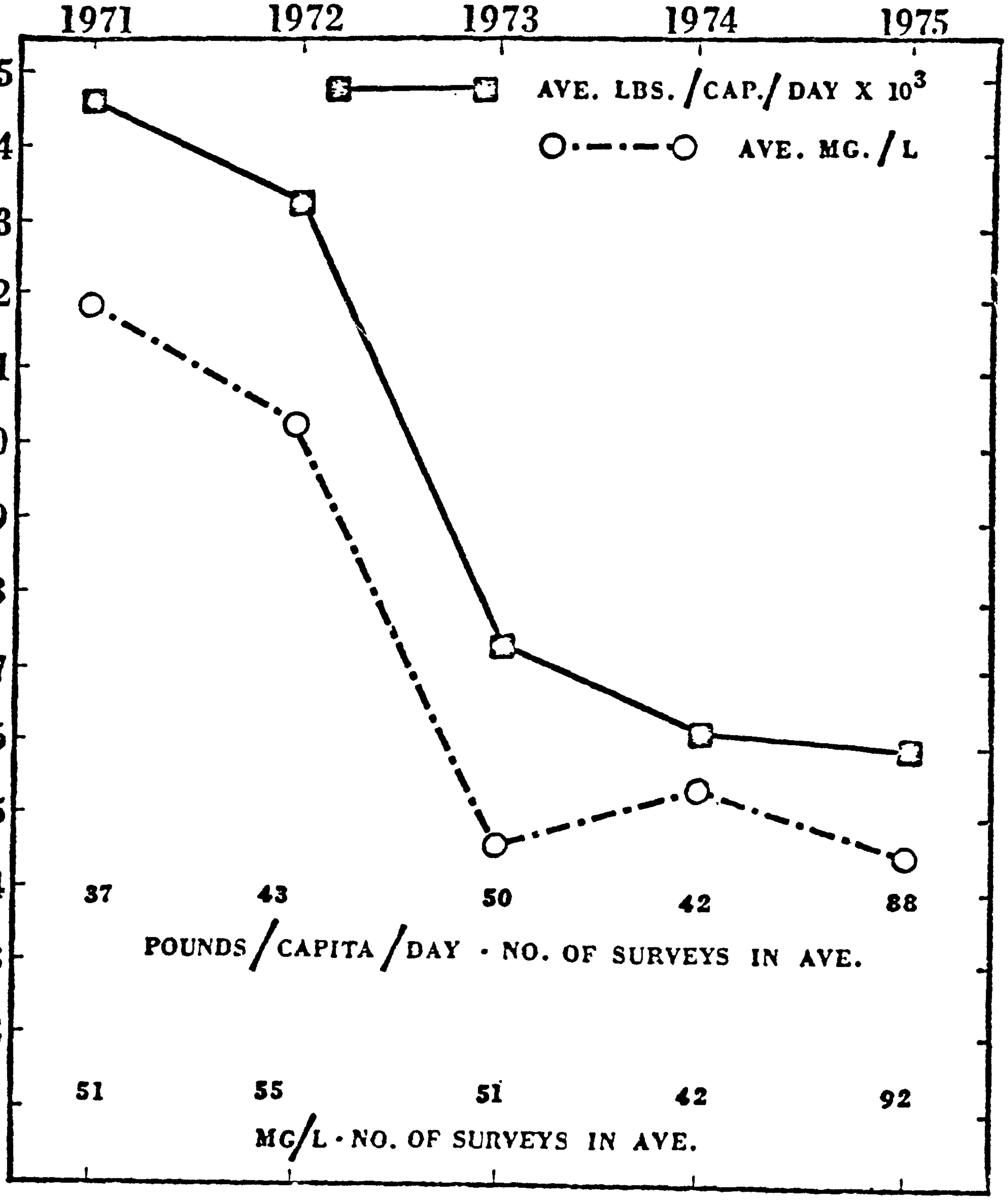
*1975 305(b) Report, Indiana Pollution Control Board pp 342-35.
** Dr. Cecil Lue-Hing, Director, Research & Development, The Metropolitan Sanitary District of Greater Chicago, Personal Communication, March 29, 1977

* PHOSPHORUS CONCENTRATIONS (mg/1)
ERIE COUNTY, NEW YORK, DATA
*Average phosphorus concentration computed for approximately 30 municipal discharges, one sample per year
PHOSPHORUS (mg/ℓ)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
1971
1972
1973
1974
1975
Maximum
Average
Minimum

Fig, A-1

FIGURE A-2
SUMMARY OF PHOSPHORUS DATA
24-HOUR SURVEYS
RAW SEWAGE AT MUNICIPAL TREATMENT PLANTS



of the West-Southwest Sewage Treatment Works does not allow us to accurately estimate what portion of the phosphorus reduction is attributable to the phosphorus ban and what portion could be attributed to other causes.

The phosphorus loads in terms of metric tons per day discharged from each of the three treatment works were determined for various time periods before and after the phosphorus detergent ban. The total average daily phosphorus load from all three plants was 14.2 tons per day for the first six months of 1972. The phosphorus loading decreased to 6.5 tons per day in the last six months of 1972 or a reduction of 53.8 percent.

The total volume of effluent discharged was slightly higher in the second half of 1972 (1411 MGD) as compared to the first half of 1972 (1357 MGD).

5. In Michigan, the average influent phosphorus loading from four municipal sewage treatment plants, decreased from 15.0 lbs/1000 people/year in 1970 to 8.8 lbs/1000 people/year in 1975 which resulted from the reduction of the average phosphorus content in detergent from 11.4% in 1970 to 7.07% in 1976.

TABLE A-1*

THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

CONCENTRATION OF PHOSPHORUS IN MG/L FOUND AT THE
MSDGC TREATMENT PLANTS
ANNUAL AVERAGES 1969-1972

Year	Calumet		Southwest			North Side	
	Raw	Final	Raw SW	Raw WS	Final	Raw	Final
1969	9.8	5.1	20.1		2.7	9.7	5.2
1970	8.6	4.7	17.3	6.2	2.3	10.6	6.1
1971	9.3	4.3	37.4		2.7	10.3	6.4
1972	7.9	2.8	12.5	5.1	1.3	4.9	3.1

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*Cecil Lue-Hing, David T. Lordi, "Report on City of Chicago's Phosphorus Ban and Its Effect Upon Effluent Quality, the Metropolitan Sanitary District of Greater Chicago. Department of Research and Development, February 1973.

A comparison was made between a period when there was no limitation on phosphorus detergents, the year 1970, and a period, November 1972, after the phosphorus ban went into effect. The phosphorus loads for the combined effluents decreased from 18.3 tons per day to 5.9 tons per day or by 67.6 percent.

Table A-2 shows numerically the continuing effects of the phosphorus ban. The North Side Plant receives a high percentage of domestic sewage. The West Southwest Plant receives over 50% of its sewage from industrial wastes. It can be observed that without any additional phosphorus removal capability, effluent phosphorus concentration decreased to below the Illinois 1 mg/l standard for the Southwest Plant which has a flow close to a billion gallons per day.

It is difficult to completely assess the effects of the phosphorus ban because of the precentage of flow from outside of the city of Chicago which is treated in the District plants. However, there has been a definite reduction in the phosphorus concentrations in both the raw sewage and the resultant treatment plant effluents. These reductions appear to be in the range of 40 to 60 percent. Improvements in the effluent concentrations reflect the reduced influent phosphorus levels and possibly may be partially a reflection of improved treatment performance.

TABLE A-2*

THE METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

CONCENTRATION OF PHOSPHORUS IN MG/L FOUND AT THE MSDGC TREATMENT PLANTS ANNUAL AVERAGES 1969-1975

Year	Southwest		North Side	
	Raw	Final	Raw	Final
1969	20.1	2.7	9.7	5.2
1970	34.0	2.3	10.6	6.1
1971	37.4	2.7	10.3	6.4
1972	14.0	1.3	4.9	3.1
1973	7.8	0.4	4.2	1.8
1974	5.8	1.0	5.8	3.2
1975 (1/2 year)	6.3	0.8	3.9	2.2

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*H.W. roston, John G. Morris, Cecil Lue-Hing, Richard S. Howe, "Meeting Phosphorus Effluent Standards Without Increasing Capital Expenditures or Operation and Maintenance Cost," September 1975

Chapter IV. Feasibility of a Detergent Phosphate Ban

The original barriers to detergent reformulation in 1971 related to the performance and safety of the substitutes then available. Progress in the development of non-phosphate detergents and their wide use in areas where bans exist have resulted in a group of commercially available non-phosphorus detergents which are safe, perform adequately, and are a feasible substitute for phosphate based detergents.

Performance and Safety of Non-Phosphate Detergents

Most modern laundry detergents use "builders" to tie up calcium ions in the wash water so that the "surfactants" or cleaning ingredients can remove dirt from the clothes. The presently available builders for detergents are phosphates (usually in the form of sodium tripolyphosphate); sodium carbonate and sodium silicate (in varying combinations); citric acid (citrate); nitrilotriacetic acid (NTA) and a number of other builders in various states of testing and experiment. Detergent builders work in one of two ways. They either "sequester" the hardness ions by chemical reaction, maintaining them in solution (phosphates, NTA, citrate), or they precipitate them out of solution (sodium carbonate/silicate).

Results regarding the performance of phosphate and non-phosphate builders are mixed. Builders of the sequestering variety are considered by most detergent industry experts to be superior in cleaning performance to the precipitating variety. Of the presently available builders, phosphates are considered to be superior by the same industry experts. However, a number of studies done by agencies and non-phosphate detergent manufacturers* have drawn the conclusion that non-phosphate detergents are as effective as phosphate detergents in cleaning ability. While NTA equals phosphates in its performance, cost, and degradability, questions have been raised about its safety and, at present, it is not available to detergent makers in this country. It is, however, used in Canada. Other builders of the sequestering and precipitating variety have been developed and are being tested by manufacturers.

In areas where phosphate detergents cannot be sold, substitutes used (in the U.S.) are sodium carbonate and sodium silicate separately or in varying combinations, citrate, and unbuilt liquid detergents, with the latter of growing popularity. There is evidence that hard water can cause an undesirable build-up of calcium carbonate precipitate to form on clothes and washing machine parts. For practical purposes, only soap and the carbonate containing detergents cause troublesome deposits to build-up on the fiber; and for these the rate and extent of deposition increase in proportion to the water hardness and carbonate content.**

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* Richard S. Howe, et al Laundry Detergents and Environmental Quality, (May 1973) Also see Table 3-10, 3-11, and 3-12.

** Schwartz, A.M., Transcript of Testimony, Minnesota Pollution Control Agency Hearings on Proposed Regulation WPC 37, (Feb. 11, 1975).

It is this calcium buildup that causes most of the problems that have occurred with carbonate-built detergents. Since the amount of build-up that occurs can be linked directly to the washwater hardness, and carbonate content detergent users in hard water areas without water conditioning equipment have experienced more problems than have users in areas of soft to medium hardness. The types of problems that have been reported range from lowered cleaning efficiency for man-made fibers (resulting in "grayness") to, in cases of extreme hardness, shortened clothing life and interference with washing machine operation.

It also should be noted that where carbonate detergents cause problems, there are other alternatives for the consumer. Users can purchase unbuilt phosphate-free liquids, at least one citrate-built liquid (Wisk), and silicate built detergent; none of which cause a calcium build-up. Water conditioning equipment will also solve the problem. The heavy-duty liquid detergents, primarily Wisk, Era, and Dynamo, made up a rapidly growing share of the laundry detergent market--19.3% in 1975. These are widely used as spotters (they are effective in removing stains on synthetic fabrics, e.g., ring-around-the-collar). They also can be used as regular detergents. Increasing sales and manufacturer's advertising indicates liquid products are now widely accepted for doing the entire wash. In the area of oily or greasy soils, liquid detergents are clearly superior to other detergents.

Several studies have tested and compared the performance of phosphate and carbonate builders. As Michigan Department of National Resources staff pointed out in a review of available studies prior to their August hearing, it is difficult to interpret the results of the studies since both the methodologies and the results varied from study to study. As might be expected, the studies sponsored by companies with ties to the phosphate detergent industry do not reach the same conclusions as those sponsored by the makers of non-phosphate detergents.

It is probably safe to conclude that the presently available non-phosphate detergents (carbonate/silicate built combinations, citrate-built and unbuilt) have comparable performance to phosphate detergents at lower hardness levels but do not perform quite as well at higher hardness levels as do phosphate detergents. In areas of extreme hardness, users of any detergent may experience laundering problems. Users of carbonate detergents are apt to experience the poorest performance and precipitate build-up may result in damage to clothing and to the washing machine. However, as already indicated, water softeners, citrate-built detergents*, and unbuilt liquid detergents, are available to alleviate impacts.

The contention was made in 1971 that non-phosphate, carbonate/silicate, detergents are a more dangerous irritant than phosphate products. However, this does not appear to apply to the brands now marketed by the major manufacturers.**

* Citrate is used as a builder in only one major brand of detergent, non-phosphate Wisk, a liquid. It is marketed primarily in areas where regular phosphate Wisk cannot be sold.

**The non-phosphate formulations presently marketed by the major manufacturers contain far less carbonates than did the non-phosphate products first introduced in the early 1970's. Whereas the carbonate content of some early products was in the 50-70% range, most major brands now average in the 20-50% range.

Tests performed by the U.S. Food and Drug Administration concluded that generalizations could not be made with respect to the safety characteristics of phosphate detergents versus non-phosphate detergents (see Howe, et al. op. cit. pp. 1-4).

Another concern raised in 1971 was that of maintaining flame retardancy in children's sleepwear. The use of non-phosphate, carbonate containing detergents can create a carbonate film which reduces the flame retardency of cotton flannel and some synthetic fabric. The problem can be avoided by switching to liquid detergents, or corrected by hand rinsing with vinegar. Most important is that 90% of the fiber now used in children's sleepwear is inherently more flame resistant. Recent tests* show that these synthetic fabrics can be washed in carbonate detergents without harming flame retardency. The same tests show that phosphate free liquids are even more effective at maintaining flame retardency than are phosphate free detergents. Many major brands of detergents, both low phosphate and non-phosphate, now warn users to read labels on these garments before washing them in anything. Whether bans are enacted or not, it is important that consumers be educated in the proper care of flame resistant garments or whether to use flame resistant garments at all.**

Rising Consumer Acceptance

The most prominent example of the acceptance of non-phosphate detergents is the large number of states and municipalities (table 2-4) that have adopted bans and kept them despite determined detergent industry opposition. Currently over 32 million persons live in areas where phosphorus in detergents has been banned. A second example of acceptance is the rapid growth in both ban and non-ban areas of the use of heavy-duty liquid detergents which are primarily non-phosphate, and constituted 19.3% of the market in 1975. A recent Michigan DNR survey in Lansing, Michigan where no ban exists showed that approximately 20% of detergents sold were non-phosphate. Complaint levels in regard to non-phosphate detergents are fairly low. Howe, et al, report a relative absence of complaints in Erie County, New York; Dade County, Florida, and in Chicago. Information obtained from cooperative extension agents in Chicago and Dade County confirms the absence of complaints in these areas. However, agents in Indiana and New York have reported laundering problems in hard water areas apparently due to carbonate detergents. Conversations by Region V staff with officials of non-phosphte detergent manufacturers, and with citizens in various areas of the midwest with phosphorus bans all indicate a very low level of consumer dissatisfaction. Region V staff feel that public sentiment, as evidenced in these conversations, public hearings, and the various studies and contacts that are referenced elsewhere in this report, indicate general public support for a phosphate ban. Members of the phosphorus committee of the regional office who authored this report are affected by the Chicago phosphorus ban. On the basis of our experience and the studies cited, we consider presently available non-phosphate detergents to be a feasible substitute in both hard and soft water.

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* Proposed Guidelines For Evaluating The Effects Of Laundering vs The Flammability of Sleepwear And Fabrics, Committee RR 38, American Association Of Textile Chemists And Colorists, July 22, 1974.

** April 1977 Consumer Products Safety Commission banned production of TRIS (2,3, Dibromopropyl phosphate) a flame retardant chemical used on children's sleepware.

Only a few formal studies are available which have surveyed consumer acceptance. One such study entitled "Detergent Substitution Studies at C.F.S. Gloucester" was done in 1973 by Environment Canada and involved a detergent substitution program conducted at a Canadian Forces Station. Carbonates, NTA, citrate, and high phosphate detergents were substituted for normal laundry detergents and a number of studies, including user acceptance were performed. Results of the opinion poll showed "a general acceptance of the NTA, citrate and high-phosphate products, with a general dislike for the carbonate product."

A second study, done in 1974 by Homemaker Testing Corporation for a phosphate manufacturer, the FMC Corporation, included as an appendix, verbatum remarks made by non-phosphate detergent users in Indianapolis, Indiana (a hard water area). Almost all of the respondents had negative statements to make in reference to problems they had with non-phosphate detergents.

A third study, cited in a Michigan Department of Natural Resources staff paper was H. Hammerman's "The Erie County Phosphate Ban--Final Report" done at Cornell University in 1973. New York residents were questioned as to their laundry habits before and after a county-wide phosphate detergent ban went into effect. It was the opinion of 80% of the people surveyed (out of a total of 397) that they spent equal time on their laundry after the ban as before and 59% stated their laundry costs were unchanged (4% said it cost them less) after the ban. The Michigan Staff paper points out that these numbers are based on each of the respondents' knowledge of their laundry habits. It is, however, not likely that all respondents kept detailed records.

Results of a similar study for Indiana were reported by Dr. William Eberly at the Michigan hearings. Of 231 women interviewed, 70% were satisfied with their detergents and of the remainder 40% still supported the Ban.

In summary, the foregoing information indicates that consumer acceptance for non-phosphate detergents is growing, particularly in soft water areas, but that some users of non-phosphate detergents in very hard water areas are still experiencing problems. Such problems however, can be reduced by the use of water softeners, heavy duty nonphosphate liquids or ordinary soap.

Water Softeners

Any discussion of family laundering costs should acknowledge the fact that approximately 6.5 million households out of a total of 67 million have home water softeners (1970 data), approximately 10 percent. The 6.5 million households are primarily in hard-water areas. According to the Water Quality Association (water softener trade association), the "prime market" for home softeners is 14.8 million to medium and high-income families who reside in single family dwellings in hard-water areas. About 40% of such families have water softener appliances. In hard-water areas, the presence of a home water softener or a city wide service can significantly reduce laundering problems as well as laundering costs through savings in detergent, additives, and energy. The softener can reduce home water heating costs as well. Where non-phosphate, carbonate-built detergents are used, a home softener can eliminate most of the precipitate and its associated problems. While the prevalence of home softeners in hard water areas can decrease the total cost of a ban, it also implies that a relatively greater cost burden rests on lower income families who cannot afford water softeners, unless such families commonly use laundromats with water softeners. Given the advantages of water softeners in energy savings, laundering, etc. more municipal water systems may find it advantageous to add water softening to the water treatment process.

Availability of Non-Phosphate Product

Because of the large number of jurisdictions now enforcing phosphate bans (see table 2-4), a large variety of non-phosphate products are now available for use and new products are constantly under development. The availability of non-phosphate products to serve a particular ban would, of course, depend on the particulars of the deadline and the distribution network in the area involved. There appears to be no particular supply problem so long as a reasonable time is provided for changeover.

ACKNOWLEDGEMENTS

Many people assisted the Committee in its work. A draft version of this report was circulated for review to members of the academic and professional community, and to concerned governmental and industrial representatives. Numerous individuals contributed to the report and the Committee is indebted to them. Although it is not possible to reference each contribution, the Committee is extremely grateful to the reviewers for the significant data and information incorporated due to their efforts. In particular, I want to acknowledge the continued assistance of Mr. Nelson Thomas, Chief, Large Lakes Research Branch, and the staff of the Large Lakes Research station for their research work and valued advise; and Dr. Joseph V. Yance, Economist, Office of Water Planning and Standards, EPA Headquarters for his incisive critique. The Committee, of course, undertakes full responsibility for the substance of the report, the conclusions, and the recommendations contained in it.

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

It is essential that steps be taken immediately to reduce the rate of eutrophication of lake waters and streams in the Great Lakes Basin. Reducing the limiting nutrient phosphorus input is the soundest measure toward reducing this rate and with present technology, the only readily controllable source of phosphorus input is sewage effluent. While treatment plants will remove phosphorus, they have not met design expectations consistently and in many cases, construction has lagged because of lack of funds. An immediate phosphorus reduction would be realized if phosphorus were banned in detergents. This is now economically and technically feasible and practical based on actual experience in areas where bans have been in effect. Substitutes for phosphorus are available that are safe and environmentally more acceptable. Therefore, U.S. Environmental Protection Agency, Region V, is now recommending that detergent phosphorus bans be adopted in all of the States in the Great Lakes Basin.

17. KEY WORDS AND DOCUMENT ANALYSIS

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