Economic Analysis of Phosphate Control:

Detergent Phosphate Limitations

vs.

Wastewater Treatment

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CONTENTS

OVERVIEW

This report reviews the existing studies, analyses and literature concerning the control of phosphorus in heavy-duty household laundry detergents as a part of the effort by regulatory authorities to retard accelerated eutrophication. Applying the standards of economic cost-benefit analysis to the issues in the controversy, the study seeks to determine the most cost-effective method for dealing with detergent phosphorus in the wastewater. The costs of the two primary policy instruments being proposed or implemented -- prohibitions on the use of phosphorus in household laundry detergents or chemical treatment at municipal wastewater treatment plants -- are evaluated and compared.

With respect to phosphate bans, a number of consumer costs are identified. Many stem from the fact that phosphate-built detergents simply perform better than commercially available alternatives under most washing conditions. Research has shown that homemakers have had to make a number of washing adjustments in ban areas to try to improve the relative performance of alternative detergent products, principally by using more hot water, detergent, bleach, packaged water conditioners, fabric softeners and pretreatment products. Problems with carbonate-built detergents, which have been the major alternative products used in ban areas, have also included greater washing machine service calls, repair and replacement, and accelerated fabric wear-out. Consumer costs from the increased installation of mechanical water softeners in ban areas have also been observed. Costs to producers of both household laundry detergent products and sodium tripolyphosphate (the major phosphate component in detergents) also exist, but cannot be measured from the information readily available. Modifying results obtained from recent studies, the consumer costs just for the extra energy consumed and the greater use of hot water, detergent and laundry additives in ban areas are estimated to be about \$11.10 per household per year. This estimate, although somewhat rough, is considered conservative because no estimate was made of other consumer costs or of producer costs which are directly attributable to phosphate bans.

Turning to chemical treatment costs, a number of recent cost studies are evaluated. Using the most recent and most supportable evidence, it is found that the chemical treatment costs necessary to remove the phosphorus attributable to household laundry detergents range from a low estimate of \$0.81 per household per year to a high estimate of \$2.10. These estimates include capital costs and operating and maintenance costs of both chemical feed systems and sludge handling and disposal.

The report therefore concludes that phosphate bans are not a cost-effective method of controlling the phosphorus in the wastewater attributable to household laundry detergents.

I. INTRODUCTION.

The ecological impact of phosphorus in man-made effluents discharged into the inland waters in the United States has been of continuing interest to federal, state and local regulatory authorities charged with water quality control since the mid-1960's. In the ensuing years, a great deal of public debate has occurred regarding the actual environmental effects of phosphorus and whether and how it should be controlled. Unfortunately, as is so often the case with environmental questions, consideration of the basic issues has often taken place in a heated, adversarial context, which has tended to obscure the complexities of the problems involved and the real costs and benefits of the alternative approaches being proposed or implemented.

The purpose of this report, which has been undertaken at the request of The Soap and Detergent Association, is to place the economic issues in the proper perspective from the standpoint of cost-benefit analysis. It is not designed to introduce fundamentally new data on the essential questions, but rather to marshall the existing evidence in a more rigorous analytical framework.

This report will first set forth the background as to why phosphorus is thought to pose an environmental issue, the nature of the current information on that issue and a general statement of the economic considerations applicable to the available alternatives for phosphorus control. We will then discuss the economic costs and benefits of the three primary approaches currently confronting regulatory authorities: (1) reducing substantially the phosphorus content in heavy-duty laundry detergents; (2) reducing phosphorus in effluent through treatment at wastewater plants; or (3) a combination of the first two approaches.

II. BACKGROUND

A. THE EUTROPHICATION PHENOMENON

Accelerated eutrophication, or the premature aging of lakes and streams, has been regarded as a major water quality problem in certain sections of the United States, particularly in the Great Lakes region. In general, eutrophication is a natural maturation process resulting from nutrient enrichment. Although not seen as a threat to human health, eutrophication results in excessive growth of algae and other aquatic weeds, leading to unsightly appearance of water bodies, decline in particular species of fish life and deterioration in water uses.*/ The

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*/ In certain rare instances, algal blooms may be toxic. However, this is not considered to be a significant problem and is due to a complex series of causes. See Wayne W. Carmichael and Paul R. Gorham, "Factors Influencing the Toxicity and Animal Susceptibility of Anabaena Flos-Aquae (Cyanophyta) Blooms," J. Phycol., 13 (1977), pp. 97-101.

proliferation of algae induced by nutrient enrichment causes algal "blooms" to appear on the water surface. As these algae die, they generate a noxious odor and unpleasant water taste and appearance. The dead algae also produce a "biological oxygen demand" in the water, acting to precipitate a pattern of bacterial activity which reduces the concentration of oxygen and which may diminish a lake's ability to sustain particular species of fish.

Nutrients, of course, enter the water continually from a number of sources as common as rainfall, the decomposition of dead fish and release from sediments. Eutrophication itself occurs naturally as bodies of water mature. Human development, however, has acted to accelerate the process by the concentrated discharge of municipal sewage and industrial wastes and the surface runoff from agricultural and urban areas.

There is no consensus as to the extent of eutrophication in the United States, but it is clear that it affects only a minority of the nation's inland waterways because many bodies of water are too deep, silted, fast-moving or cold to become eutrophic. Nonetheless, in certain areas of the country, such as portions of the Great Lakes Basin, eutrophication continues to be of concern.

B. THE LIMITING NUTRIENT CONCEPT.

Many elements contribute to the eutrophication process, including over twenty different kinds of nutrients. Attention, however, has centered primarily on phosphorus. An understanding of why this is so involves an appreciation of a theory called "Leibig's Law of the Minimum." This hypothesis, which has been restyled as the "Limiting Nutrient Concept," holds that the proliferation of algae can be controlled by limiting those elements which are in the shortest supply in relation to all of the elements necessary for its growth. It follows, then, that if the "limiting" nutrients can be restricted, this will act to retard further algal growth. Applying this analysis, phosphorus, as an essential building block for all living organisms, was identified as one of the key "limiting" nutrients.

Phosphorus, as phosphate,*/ is not the nutrient solely, or even principally, responsible for algal growth. In fact, algae require significantly greater proportions of carbon, oxygen, hydrogen and nitrogen than phosphorus. Phosphorus, however, has been considered to be the most controllable since much of the phosphorus entering the water is thought to be derived from man-generated sources. Early in the discussion one widely-cited commentator argued that of the 21 basic nutrients necessary for algal growth, only one - phosphorus - met the dual criteria of being both growth-controlling in lakes and controllable by man.**/

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*/ The element, phosphorus, does not occur freely in nature. It is found in its simplest form in the environment as phosphate.

**/ J. R. Vallentyne, "Phosphorus and the Control of Eutrophication," Canadian Research and Development, May-June, 1970, pp. 36-49.

C. SOURCES OF PHOSPHORUS IN WATER BODIES.

Phosphorus enters the water in a variety of ways. Natural sources include decaying leaves and plants, soil erosion, dissolved matter in rain and snow, animal wastes, runoff of surface water and dusts from the atmosphere. Man-derived sources are primarily municipal sewage, industrial wastewaters, and animal feedlot and grazing land waste as well as the runoff of agricultural and urban areas. The most important source of phosphorus in domestic wastewater now appears to be human waste. Another significant contributor is phosphorus-containing heavy-duty laundry detergents.

D. PHOSPHATES IN HEAVY-DUTY LAUNDRY DETERGENTS.

A principal ingredient in all laundry detergents is the surfactant (surface active agent), which is the essential cleaning agent. Surfactants, however, are more efficient in basic cleaning performance when they are combined with other chemicals called "builders." Builders bring about conditions in the wash water which both permit the surfactants to work much more effectively and reduce the amount of surfactants necessary. Since just after World War II, phosphate compounds have been the principal builders in laundry detergents in this country, allowing synthetic detergents largely to replace soap in the washing process. The phosphate builder, usually sodium tripolyphosphate (STPP), acts to remove oil and dirt from cloth fibers by providing mild alkalinity and by loosening soil particles, and then holding them in suspension after they have been removed. It also sequesters the minerals which produce hardness (mainly calcium and magnesium) in water which otherwise interfere with laundering performance.

Phosphorus, as elemental phosphorus, accounted for about 9% to 12% of laundry detergent content in 1970. Since then, this percentage has been reduced significantly. Detergent phosphorus content was estimated in late 1976 to average about 6% in non-ban states;*/ it is probably somewhat less than that today.**/

During the three decades that phosphates have been in widespread use in detergents, they have shown themselves to be unusually hazard-free compounds. Its safety for human use

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*/ Communication of Mr. W. J. Schuette of Procter & Gamble Co. to Mr. Swep T. Davis, Director, Office of Analysis and Evaluation, U.S. Environmental Protection Agency (U.S. E.P.A.) November 10, 1976. This estimate seems generally consistent with U.S. E.P.A. data. They calculated the average phosphorus content in laundry detergent to have been reduced from 11.4% in 1970 to 7.07% in 1976. Letter from Mr. Swep T. Davis, U.S. E.P.A., to Mr. James Pacheco, FMC Corp., dated December 3, 1976, unpaginated.

**/ The Soap and Detergent Association estimates that laundry detergents in areas unaffected by phosphate bans in the U.S. portion of the Great Lakes Basin have an average phosphorus concentration of 5.5%, down from 10.8% in 1970. "Phosphate Loadings to the Great Lakes from Detergents," The Soap and Detergent Association, September 21, 1979, p. 1.

has been fully documented.*/

For the purposes of this report, the term, "detergents," is meant to refer to laundry detergents intended for household use, which have been the principal targets of phosphate bans or restrictions. These restraints have not generally been directed at detergent formulations used in automatic dishwashers or those employed in industrial or institutional applications.

E. LEGISLATIVE BACKGROUND.

Phosphate control emerged as an important public policy issue in the United States as a result of meetings of the Lake Erie Enforcement Conference on water quality in 1965 and the Lake Michigan Enforcement Conference in 1966. Relying on technical reports of these conferences, Stewart Udall, then Secretary of the Interior, vigorously urged the soap and detergent manufacturers in mid-1967 to find a replacement for phosphates in detergents.**/ Increasing governmental pressure was applied to the industry to find an acceptable substitute, particularly after the release in October, 1969 of a report by the International Joint Commission (I.J.C.) calling accelerated

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*/ See, for example, Evaluation of the Health Aspects of Phosphates as Food Ingredients, (1975), prepared under contract for the Food and Drug Administration, U.S. Department of Health, Education and Welfare, by the Life Sciences Research Office, Federation of American Societies for Experimental Biology, Bethesda, Maryland.

**/ "Fact and Foam in the Row Over Phosphates," Fortune, January, 1972, p. 73.

eutrophication "the most serious water pollution problem in the lower Great Lakes." The I.J.C., the agency charged with reconciling problems and coordinating action on joint issues affecting the United States and Canada, recommended controls on the phosphorus content in detergents and phosphorus removal by improved municipal and industrial wastewater treatment in the Great Lakes Basin area.

The Canadian government reacted quickly and inaugurated reduction of phosphate in detergents to its current maximum of 2.2% elemental phosphorus (by weight), achieved in 1973, as well as increasing the funding of advanced wastewater treatment at the local level. Canadian producers gradually replaced a portion of the phosphates in detergents with sodium nitrilotriacetate (NTA). When used in combination with some phosphate, this provides an adequate builder system both in terms of washing performance and price.

In the United States, Congressional committees and numerous governmental agencies, including the Departments of Commerce and Interior and the President's Council on Environmental Quality, began insisting that NTA be used in place of phosphate. These efforts ground suddenly to a halt in late 1970 and early 1971 when it was conjectured on the basis of preliminary laboratory experiments that NTA in conjunction with heavy metals might cause birth defects. As a result of these tests, the Department of Health, Education and Welfare, the U.S. E.P.A. and the Council on Environmental Quality announced jointly in September, 1971, that until sufficient data became available, NTA should not be used in detergents.*/ The federal regulatory authorities then urged an immediate return to the use of phosphate detergents and reverted to their original position of stressing wastewater treatment as the most appropriate method of phosphate removal. Dr. Jesse Steinfeld, Surgeon General at the time, characterized the rush toward phosphate substitutes which occurred in the early 1970's as a "simple, hasty, politically expedient solution to a complex, scientific, regulatory issue" and as "a classic case of environmental extremism and governmental ineptitude."**/

State and local governments, however, had already been caught up in the emotional reaction to phosphates and had begun to implement restrictions on detergent phosphorus content at a furious pace. In 1971, legislation limiting the phosphorus content of detergents to 8.7% became effective in Chicago, Illinois; Akron, Ohio; and Dade County, Florida.

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*/ Since late 1970, the major detergent manufacturers have voluntarily refrained from using NTA in laundry detergents in the United States. In May 1980, EPA released the results of a health and environmental risk assessment on the use of NTA in laundry detergents. The Agency found that "projected levels of exposure from the use of this substance (NTA) in laundry detergents are generally low and therefore that the associated risks would also be low. Based on these findings and on the higher priority demands on EPA's limited resources, EPA sees no reason to take regulatory action against the resumed production and use of this substance for laundry detergents." "Fact Sheet: NTA," U.S. E.P.A., Office of Pesticides and Toxic Substances, May, 1980. As of the date of this report, no change in industry usage of NTA has been reported.

**/ Jesse L. Steinfeld, "Behind the Great Phosphate Flap," Reader's Digest, November, 1973, pp. 2 and 6.

In 1972, similar legislation became effective in the states of New York, Michigan and Indiana. Total bans*/ on phosphates in detergents were effective in Dade County and Chicago in 1972 and in Indiana, New York and Akron, Ohio in 1973. A number of jurisdictions subsequently passed similar restrictive legislation, either as an outright ban or as a limitation on detergent phosphate content. The Appendix shows those states and municipalities which have instituted laws restricting the phosphorus content in detergents; by July, 1979, 27.5% of the U.S. population was covered by some kind of phosphate limitation, including 22.0% of the population which was covered by an absolute prohibition.

The U.S. Federal Government, on a regional basis, has now also shifted its position once again. In June, 1977, Region V of the U.S. E.P.A. announced that it now advocated that all states in the Great Lakes area should "give urgent consideration to the adoption of a ban on phosphorus in detergents."**/ While not tantamount to an actual federal prohibition, the Agency stated that it "will provide technical assistance and expertise on this issue to all regulatory and

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*/ "Total" or "absolute" bans or limitations really means that no more than 0.5% elemental phosphorus by weight is allowed because trace amounts may always be present.

**/ U.S. E.P.A., Office of the Regional Administrator, Region V, Detergent Phosphate Ban, Position Paper prepared by Region V Phosphorus Committee, June, 1977, p. 1.

legislative agencies in the (Great Lakes) states." */

The Federal Government meanwhile has moved forward on wastewater treatment as a means to remove phosphate. The Great Lakes Water Quality Agreement of 1972 between the U.S. and Canada set as a goal a one milligram per liter (1 mg/L) phosphorus effluent limitation for all municipal treatment plants which discharge in excess of one million gallons per day into the Great Lakes. There has been progress toward this objective, although the pace does not seem totally satisfactory. **/ Further, through the Clean Water Act, the Federal government has obligated substantial funds toward improving wastewater treatment facilities. Section 208 of that Act provides for local and state agencies to develop and implement water quality treatment plans. Under the provisions of this section, many localities are to determine the nature of their water quality control activities for years to come. In areas where nutrient control is considered necessary, these plans may, of course, involve wastewater treatment nutrient removal, phosphate bans or limitations, diffuse source control, or a combination of any of these approaches. Detergent phosphate control has become a

*/ Ibid., p. 5.

**/ As the I.J.C.'s Great Lakes Water Quality Control Board said in 1978, "The total municipal input into the Lower Lakes continues to far exceed the limitation in the 1972 Agreement." Sixth Annual Report (1977) to the International Joint Commission, Great Lakes Water Quality Board (July, 1978), p. 4.

pressing policy question for a number of communities across the country.

III. STATEMENT OF THE PROBLEM

A. BENEFITS FROM THE CONTROL OF DETERGENT PHOSPHATE.

We begin with the fundamental hypothesis that the costs associated with the reduction of detergent phosphate by whatever means should be justified by tangible corresponding benefits. The benefits sought in this instance would be a retardation of the aging process of the waterways affected. Because health and safety considerations are not an issue,*/ this should be expected to result in an improvement of general environmental quality, specifically in increased recreational activity and improved drinking water.**/

*/ As mentioned earlier, accelerated eutrophication does not significantly affect human health or safety. However, in a cost-benefit setting, this can become an issue to the extent that phosphate substitutes are not as safe.

**/ Other than recreation and better drinking water, the other benefits are ambiguous. For example, reduction of accelerated eutrophication may increase certain species of fish, such as trout, but it can also result in the diminution of other species. As pointed out in a recent study, "For many lakes, the increased productivity of fish associated with some eutrophication is an important benefit and one that would make it difficult to justify a return to an oligotrophic (i.e., non-eutrophic) state." James E. Ciecka, et. al., An Economic Analysis of Phosphorus Control and Other Aspects of R76-1, Economic Evaluation Associates, Inc. for the State of Illinois, Institute for Environmental Quality, June, 1978, p. 11.

There are really two aspects to the benefits question. The first is whether the control of phosphorus generally will have an effect on retarding eutrophication. Assuming that such a relationship does exist, the second issue is whether controlling detergent phosphate alone is sufficient to have a significant effect on water quality.

The first proposition was the subject of considerable controversy throughout the late 1960's and the early 1970's among scientists and limnologists. Despite some undercurrents of dissent, the "conventional wisdom" now seems to be that, for most bodies of fresh water, phosphorus is frequently the most controlling and controllable element in accelerated eutrophication.*/ However, even assuming the general control of phosphorus could be expected to lead to the desired results, there is considerable doubt that regulation of detergent phosphate alone will have any meaningful impact.

To put this latter issue in proper perspective, it is necessary to consider the extent of phosphorus contribution from detergents compared to that from other sources in the environment. As observed earlier, phosphorus enters the nation's waterways from a number of different sources. Some of these are as uncontrollable as decay of organic matters, rainfall, and

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*/ There is increasing evidence that in non-fresh water bodies, such as estuaries, nitrogen may be the growth controlling element. See Thomas P. Flaherty and Robert H. Harris, Impact of Nutrients on the Potomac Estuary, Environmental Defense Fund, Washington, D.C. December, 1979. On p. vi of this report, the authors state, "it is concluded that nitrogen, and not phosphorus, was growth limiting" in the Potomac Estuary.

atmospheric transference, all of which may be important sources. The U.S. E.P.A., Region V, has indicated, for example, that, "it has now been established that a significant percent of the phosphorus loadings of the (Great) lakes is input from the atmosphere."*/ Others are controllable, including phosphorus entering the waterways from industrial wastewater, runoff of agricultural and urban areas, animal wastes and municipal wastewater. In addition to detergents, this latter source includes human sewage, kitchen wastes, other household cleaning products and, often, some industrial waste.

While the relative contribution of detergent phosphate to the aggregate amount entering the nation's waterways remains the subject to some debate, it is clearly a minority of the total. Early estimates (1971) were that perhaps as much as 30% to 42% of all phosphorus going into inland lakes and streams came from laundry detergents.**/ However, the role of laundry detergents is now known to be significantly less for three reasons: (1) non-point sources of phosphorus contribute greater quantities of phosphorus than had been thought previously; (2) the average phosphorus content of detergents has fallen by 33%

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*/ U.S. E.P.A., Detergent Phosphate Ban, Op. Cit., p. 2.

**/ Kathleen F. Doyle, "Phosphates - An Unresolved Water Quality Problem," Environmental Reporter, Vol. 2, No. 16 (August 20, 1971), Monograph No. 9, Bureau of National Affairs, Washington, D.C., p. 4. See also Richard D. Grandy, "Strategies for Control of Man-Made Eutrophication," Environmental Science and Technology, 4 (September, 1970), pp. 725-6.

to 50% in non-ban areas; */ and (3) much more phosphorus is now being removed by chemical treatment of wastewater.

If detergent phosphate is in fact such a limited factor in overall phosphorus contribution, there is a real question as to whether its removal alone will provide positive benefits. This concern is particularly critical in light of recent research which indicates that substantial reductions of phosphorus loadings are necessary to achieve significant improvements in water quality. For example, a report in June, 1978 to the State of Illinois Institute for Environmental Quality, observed that "the relationship between the productivity of a lake and its phosphorus content is not linear," but curvilinear. Referring to the following diagram, the authors point out that for a lake which falls in the B region of the curve, "chiefly mesotrophic lakes," **/ a diminution of phosphorus inputs would be reflected in a parallel reduction in obvious eutrophication problems. However, "most eutrophic lakes fall into Part A of the curve. Thus, to get dramatic improvements, the phosphorus concentration

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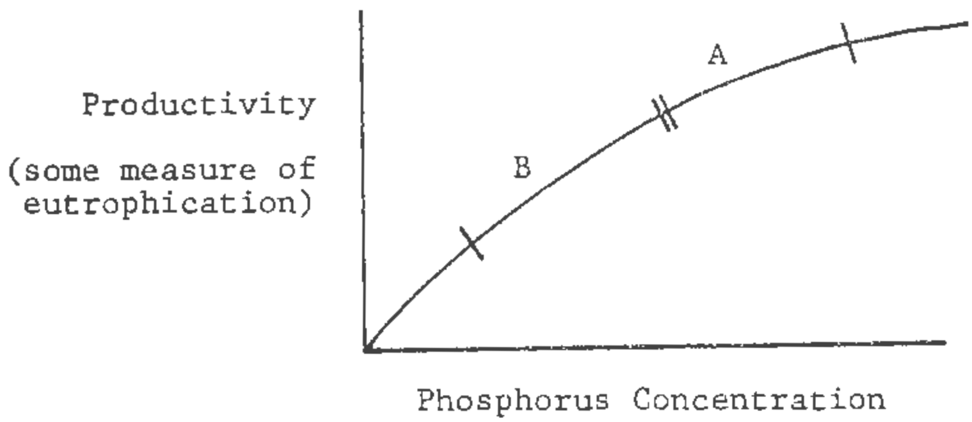
*/ See the first footnote on page 6 of this report. This downward trend is further corroborated by the fact that the tonnage production of STPP, the principal phosphate compound used in detergents, has been declining significantly, at a rate of 4% a year from 1967 to 1976, even as total detergent production continued to grow. The Kline Guide to the Chemical Industry, 3rd Ed. (Fairfield, N.J., Charles H. Kline & Co., Inc., 1977), p. 74.

**/ "Eutrophic" lakes are those which have a high potential concentration of nutrients and are well-nourished. "Oligotrophic" lakes are those which are poorly nourished. The intermediate state is called "mesotrophic."

must be greatly reduced. Thus the inputs of phosphorus must be greatly reduced."*/



This is also recognized in another recent study where it is stated that, "relatively large changes in P load must be effected in order to have significant changes in water quality and that with few exceptions, the amount of P derived from detergents is a small percentage of a lake's total

*/ Ciecka, et al., An Economic Analysis of Phosphorus Control and Other Aspects of R76-1, Op. Cit., p. 9. (Emphasis supplied).

load."*/ **/

That the substantial reduction or elimination of the phosphorus content of detergents alone is not a sufficient solution for water quality control has also been recognized by the leading proponents of phosphate control:

> Even if phosphates are completely removed from detergent products, the need for efficient operation of treatment plants will remain as there are other sources of phosphorus, notably human wastes, that are expected to increase in quantity over time and that will require treatment. ***/

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*/ G. Fred Lee, Walter Rast and R. Anne Jones, "Use of the OECD Eutrophication Modeling Approach for Assessing Great Lakes Water Quality," Occasional Paper, July, 1979, p. 211. (Portion of a report accepted by the National Oceanic and Atmospheric Administration).

**/ A Corps of Engineers' study last year reiterated an earlier finding that if municipal point sources with a flow greater than one million gallons per day are required to achieve effluent phosphorus concentrations of one milligram per liter, or even 0.5 milligram per liter, the control of diffuse sources of phosphorus would still be required "to restore Lake Erie." Lake Erie Wastewater Management Study, Methodology Report, U.S. Army Engineer District, Buffalo, March, 1979, Syllabus and pp. 121-126. Another recent paper similarly found that even if the one milligram per liter restriction were extended to all point source discharges of phosphorus throughout the entire Great Lakes system, reduction of diffuse sources might still be necessary "to bring about return to acceptable trophic conditions" for large areas of the Lakes (western Lake Erie, lower Green Bay and Saginaw Bay). Steven C. Chapra and Andrew Robertson," Great Lakes Eutrophication: The Effect of Point Source Control of Total Phosphorus," Science, Vol. 196, June 24, 1977, pp. 1448-1449.

***/ International Joint Commission, Fifth Annual Report - Great Lakes Water Quality, 1976, unpaginated.

and:

> 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/1 (1 milligram per liter) total phosphorus effluent limitation limitation (sic) goal. */

B. PHOSPHORUS CONTROL POLICY ALTERNATIVES.

In general, regulatory authorities have considered three main policy options to obtain a reduction or elimination of phosphorus in municipal wastewater effluents. These are chemical treatment at wastewater treatment plants, **/ elimination or reduction of the phosphorus content in detergents or a combination of these two approaches. A combined approach is often proposed in order to reduce the treatment costs of removing phosphorus at the wastewater facility.

C. MEASUREMENT OF COSTS.

Each of these policy approaches has significant costs associated with it. The sort of costs of chemical treatment necessary to remove phosphorus from wastewater are fairly well-defined because they involve direct expenditures for specific purposes, though they can vary depending on the

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*/ U.S. E.P.A., Detergent Phosphate Ban, Op. Cit., p. 36.

**/ Other alternatives to chemical treatment in wastewater treatment plants, viz., land treatment and "luxury" biological removal, are far less common. These are discussed in greater detail later in this paper.

particular circumstances of the treatment plant. The consumer and producer costs associated with phosphate bans are far less clear and more diffuse than those of chemical treatment. In fact, some of the costs are often difficult to discern by consumers as being due to a ban at all. They are nonetheless as real as those of chemical treatment.

Chemical treatment to remove phosphorus is an additional process installed by a wastewater treatment facility. There is an issue of whether all of the costs of chemical treatment are properly assigned to detergent phosphate removal because the phosphorus is being removed from all municipal sources (i.e., including human waste, kitchen sewage, and other cleaning products and some industrial waste).*/ If society will accept the phosphorus level remaining in water bodies after eliminating phosphates from detergents, then most, if not all, phosphorus removal water treatment costs should be considered due to detergent phosphorus content. In that case, control of detergent phosphorus content would eliminate any need for chemical treatment. On the other hand, if society insists on reducing effluent phosphorus concentrations to even lower levels than that achieved by eliminating phosphates from detergents, most, if not all, phosphorus removal wastewater treatment

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*/ In the case of land treatment and "luxury" biological phosphorus removal, which are alternatives to chemical treatment, the costs are not related to the phosphorus concentration in the wastewater.

costs should be attributed to factors other than detergents. In the latter case, the chemical treatment costs caused by the detergents' phosphorus content are only the incremental costs incurred by the removal of the phosphorus contributed to wastewaters by detergents.

No proponent of a phosphate ban was found who demonstrated that additional wastewater phosphorus reduction would not be necessary. On the contrary, it was usually affirmatively stated that additional phosphorus removal at municipal wastewater treatment facilities would be required.*/ Thus, when comparing chemical treatment to a phosphate ban, the appropriate costs to consider are the marginal chemical treatment costs directly associated with the removal of detergent phosphate.

D. APPROACH TO THE ANALYSIS.

For the purposes of the remainder of this paper, we will assume that there are benefits (increased recreational activity and improved drinking water) associated with a reduction of phosphorus loadings of municipal wastewater effluents into inland lakes and waterways. We will further assume the benefits are equal to, or exceed, the costs of mandating such a reduction where the limitation is set at one milligram per liter (1 mg/L) for municipal treatment plants. We will then

*/ See p. 17 and 18 for excerpted comments by the E.P.A. and the I.J.C.'s Water Quality Board.

survey the costs related to the principal policy options proposed to achieve this objective -- chemical treatment, wastewater treatment facilities and restrictions on detergent phosphate. At the conclusion, the costs of each approach are discussed and a comparison of the costs is made.

We will now turn to an evaluation of the available evidence on the costs associated with each approach.

IV. COSTS ASSOCIATED WITH A PROHIBITION OF DETERGENT PHOSPHATE.

A. CONSUMER COSTS.

1. GENERAL.

Precise measurement of the costs to consumers of the elimination of phosphates in household laundry detergents is very difficult for a number of reasons. These costs can vary depending on (1) the detergents which are used as alternatives to the phosphate-built product; (2) the mineral hardness of the water used in the washing process, which differs considerably around the country; (3) the general types of fabrics which are being laundered and (4) the kinds of soils and stains on the fabric; (5) water temperatures; (6) types of washing machines; (7) sizes of washloads; (8) differences in the amounts of detergent used; (9) differences in fabric weaves and finishes, (10) consumer preferences for certain detergent compositions (e.g., powders versus liquids), as well as other factors. With such a large number of variables affecting the outcome of the laundering process, it is a complex task to sort out the effects of altering one particular element -- in this case, the type of detergent being used -- so that the results can be generalized with some meaningful degree of confidence.

However, it seems to be commonly recognized that the phosphate substitutes commercially available in the U.S. are generally inferior to phosphate-built detergents. For example:

> The non-phosphate detergents are more costly to use than their equivalent phosphate formulations. In most cases the phosphate detergents do a better cleaning job than the non-phosphate kinds . . . */

> In summary, the data I have presented to you today show that non-phosphate detergents, compared to low phosphate detergents, can have serious deficiencies in four performance areas: poor washability, high alkalinity, poor cold water solubility, detergent residue build-up on fabrics. **/

*/ "Laundry Detergents," Consumer Research Magazine, September, 1975, p. 75.

**/ Address by Beverly J. Rutkowski, Senior Research Chemist, Science Research Department, Whirlpool Corp., entitled "Performance Characteristics of Non-Phosphate Detergents," before Michigan National Resources Commission, December 8, 1976 (mimeo), p.5. See also statement by Sally Malobabic, Product Home Economist, Customer Assurance, Whirlpool Corp., before a committee, State of Ohio, September, 1979 (mimeo).

> I know of no non-phosphate detergent product which performs as well as did the original high-phosphate products, or even the current low-phosphate products, in regard to washability performance. */

and:

> To date, there is no available substitute for detergent phosphates in efficiency, safety or cost. **/

Another source indicates that "cleaning effectiveness would suffer sharply" if detergent reformulation removed phosphates.***/ Leading proponents of phosphate bans have also found poorer performance by non-phosphate detergents, although under more limited conditions.****/

It thus appears that under most washing conditions, phosphate-built detergents perform better than their non-phosphate counterparts. One exception would be that liquid detergents

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*/ Testimony by Robert Shuck, Chemist, Laundering Fundamentals, General Electric Company, to the Committee on Energy and Environment, State of Ohio, March 13, 1978. Mr. Shuck has fifteen years of direct involvement with textiles and detergent chemistry in home washing systems.

**/ The Kline Guide to the Chemical Industry, Op. Cit., p. 78. This Kline Guide was published in December, 1977.

***/ "An Analysis of the Sodium Tripoly Phosphate Business," a report by the Institutional Department of Butcher & Singer (a brokerage house), February 3, 1975, p. 23.

****/ Region V, U.S. E.P.A. recognized that presently available non-phosphate detergents "do not perform as well at higher hardness levels as do phosphate detergents." Region V, U.S. E.P.A. Detergent Phosphate Ban, Op. Cit., p. 58. The regional office, however, apparently made no independent study to ascertain the extent of costs associated with bans, nor did it appear to consider fully the implications of the available evidence on the issue.

with a high surfactant level are superior in their ability to remove oily or greasy soils. The most significant problems related to using non-phosphate granular detergents -- granular detergents account for most laundry detergent sales*/ -- are poor solubility, limited cleaning performance, and reactions with water hardness ions to form insoluble residues which deposit on fabric and washing machine parts. These problems have led to the need for using larger amounts of hot water, detergent, bleach, fabric softener, spot pretreatment, pre-soak and other performance aids, and to increased repair and replacement of washing machines and washing machine parts, greater rate of replacement of washable fabrics, and the increased installation of mechanical water softeners.

We will turn to a specific evaluation of these factors and of the general consumer experience with phosphate bans, but first it is necessary to discuss two variables which can have a major effect on the observed results: the type of phosphate substitute used and the relative hardness of the water used in the washing process.

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*/ Granular detergents accounted for about 79% of laundry detergent dollar sales by supermarkets with $1 million or more in total sales in 1979. Chain Store Age/Supermarkets, July, 1980, p. 204.

2. COMMERCIALLY AVAILABLE ALTERNATIVES TO PHOSPHATE BUILDERS. */

Because phosphate builders in laundry detergents "are capable of performing so many tasks so well,"**/ adequate replacements in terms of performance and price have been difficult to develop. Phosphates act to increase the activity of surfactants, soften water by sequestering calcium and magnesium ions that cause hardness, dissolve precipitates of hardness ions, neutralize fatty acid soils to form a soap, disperse soil aggregates into small particles, suspend soil particles and emulsify oily soils.***/ Alternative builders available do not combine these attributes nearly as well and, as a result, have been shown to be considerably poorer in general washing performance.****/

*/ NTA, as mentioned earlier, is not used in this country at the present time and its future as a potential builder in the U.S. remains unclear. Other possible builders such as the polycarboxylates (e.g., carboxymethylene oxysuccinate and disodium oxydiacetate) are not in widespread use.

**/ Rose Lee Glee, Effectiveness of High-Phosphate, Low-Phosphate and No-Phosphate Detergents on the Removal of Soil and on Whiteness Retention on Fabrics of Varying Fiber Content, Ph.D. dissertation, University of Wisconsin, (University Microfilms, 1973), p. 26.

***/ Rutkowski, Op. Cit., Table 2.

****/ Rutkowski, Op. Cit., pp. 2,5 and Table 5.

The principal detergent systems which are currently marketed in the U.S. as alternatives to phosphate-built detergents are those which use the following builders singly or in some combination: sodium carbonate, sodium silicate, sodium citrate, sodium aluminosilicate (type A zeolite) or those "unbuilt" detergents using higher levels of surfactants. Sodium carbonate is by far the most widely used alternative for phosphate in granular detergents. Sodium carbonate reacts with water hardness to form insoluble calcium carbonate which precipitates (or settles) out of solution and deposits on the surfaces of fabrics, on the parts of washing machines and on pipes. Carbonates have high alkalinity and are "much less effective than phosphates in controlling hardness and suspending soil," making it more difficult in particular to clean heavily soiled items.*/

Sodium silicates have been used as replacement builders for phosphates. Silicates have some (albeit inferior) soil suspending capabilities and they soften the water by precipitating hardness ions, though less effectively than carbonates. They can neutralize acid soils but have only limited emulsifying abilities.**/ Due to their relatively poor soil dispersion properties, redeposition of residue is a problem. For these

*/ Rose Lee Glee, Op. Cit., p. 26.

**/ Rutkowski, Op. Cit., Table 5.

reasons, sodium silicates are "not as effective for detergent builders as phosphates."*/

Sodium citrate is a much more expensive replacement builder which is used in liquid detergents. It is seen as being "marginally effective" as an alternative to phosphate**/ or "less effective" than phosphate***/ because of its inadequate buffering and soil dispersion capabilities and its weak sequestering properties.

Zeolite builders (Type A) have been marketed nationally as a partial replacement for phosphates since about 1978. Type A zeolites capture calcium hardness ions well, but are not nearly so effective in acting on magnesium ions. For this reason, and because they are not as efficient in holding soils in solution, type A zeolites can only perform part of the job that phosphates do. In fact, type A zeolites have been used primarily in conjunction with phosphates in detergents (replacing up to half of the phosphorus content).

High surfactant, non-phosphate liquid products have been used as an alternative to traditional phosphate products. These are unbuilt and rely on the relatively high levels of hardness insensitive surfactant systems to perform the cleaning function.

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*/ Rose Lee Glee, Op. Cit., p. 28.

**/ Ibid., pp. 33-34.

***/ Wanda Olson, "Using Non-phosphate Detergents in Machine Laundry," Agricultural Extension Service, University of Minnesota, Fact Sheet No. 38 (Revised 1977), footnote 1.

Liquid detergents utilize more petroleum-based ingredients, and thus can be expected to cost more than their granular counterparts. Liquid products have not received the same level of consumer acceptance as granular detergents and are seldom used by consumers as their only detergent product. Liquids appear to make up about 21% of laundry detergent sales overall.*/

Carbonate-built detergents, and to a lesser extent, the silicate-built detergents,**/ are the principal alternatives used by consumers in localities prohibiting the use of phosphate-built detergents. In fact, carbonate-based granular products are estimated to account for about 63% of all detergents sold in areas where phosphate-built laundry detergents are no longer sold (versus 7% in non-ban areas).***/

3. EFFECT OF WATER HARDNESS ON DETERGENT PERFORMANCE.

The degree of water hardness can have a significant effect on washing performance and on the costs associated with available phosphate alternatives. The percent of the population covered by various degrees of water hardness is shown in

*/ Chain Store Age/Supermarkets, Op. Cit.

**/ Carbonates and silicates may be blended together in the same product.

***/ "The Economic Impact of Phosphate Laundry Detergent Bans on Consumers," The Soap and Detergent Association, January 3, 1980, p. 8.

Table I. The hardness problem, which is basically attributable to calcium and magnesium in the water, is summarized as follows:

> Hardness minerals interfere with the efficiency of dishwashers, water heaters, and automatic washers and the cleaning processes in the home. Rings in the bathtub, grayish laundry, streaked and spotted china, irritation to sensitive skin, reduced fabric wear, mineral deposit in pipes and water using appliances, and increased soap and detergent usage are problems attributed to hard water in the home. */

Phosphate detergents act exceptionally well in hard water by sequestering, or tying up, hard water minerals in a soluble form which washes away. The predominant phosphate alternative, sodium carbonate, reacts poorly in hard water because it acts to force the minerals out of the water in a granular residue which is redeposited on fabrics, washing machine parts and household plumbing.

*/ Susan Ballard Lester, Effects of Level of Training on Satisfactions and Benefits Derived with Softened Versus Hard Water, M.S. Thesis, Purdue University (August 1974), p. 6.

TABLE I

PERCENT OF POPULATION
BY DEGREE OF WATER HARDNESS

(1970)

Degree of Water Hardness	Range Covered */	Percent of Population Covered
Soft	(0-3.5 gpg) (0-60 ppm)	36%
Medium Hard	(3.6-9 gpg) (61-154 ppm)	46%
Hard	(9.1-15 gpg) (155-257 ppm)	10%
Very Hard	(Over 15 gpg) (Over 257 ppm)	8%
		100%

*/ Degree of hardness is in terms of the amount of calcium carbonate (Ca CO_3) in the water, expressed either as grains per gallon (gpg) or parts per million (ppm).

Source: U.S. Geological Survey (1952) of 1,315 larger U.S. cities and Rand McNally Atlas for 1970 Census data.

The performance differences between phosphate-built products and carbonate-built detergents in soft water are somewhat less clear. Some commentators have indicated that there is no performance difference in soft water. However, the effects should still occur, but proportionately less so. These effects will probably always be non-negligible since some hardness in the water is always encountered, from the soil in dirty clothing if from nothing else. The U.S. E.P.A., Region V, recognized that "the rate and extent of deposition (of calcium carbonate precipitates on clothing and washing machine parts) increase in proportion to the water hardness and carbonate content."*/ General Electric has also observed: "The build-up of calcium carbonate in cotton fabrics increases with reported washings at a rate directly proportional to water hardness ..."**/ For the purposes of this paper, then, we shall assume that these effects for carbonate detergents occur in soft water and increase in a linear relationship as harder water is encountered.

With respect to the relationship between the degree of water hardness and the soil removal ability of non-phosphate detergents other than carbonates, it has been observed that they all have comparatively poorer performances in harder water,

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*/ Detergent Phosphate Ban, Op. Cit., p. 57.

**/ Leaflet published by General Electric Co. entitled "Carbonate Detergents and Their Effect Upon Clothing and Home Laundry Equipment," (1973 or 1974), p. 2.

as well as softer water. For example:

> They (non-phosphate detergents) are equally poor in moderately and very hard water. Although performance of low phosphate detergents is decreased in harder water, their performance can be improved by using more detergent. This is not true for non-phosphate detergents. No matter how much non-phosphate detergent is used, performance cannot be improved beyond a certain level. The reason is that non-phosphate detergent builders, carbonate or silicate, contribute little to detergency beyond softening water, therefore increasing their concentration beyond that needed to soften the water will not improve performance. */

4. CONSUMER EXPERIENCE IN PHOSPHATE BAN AREAS.

A number of studies attempting to evaluate consumer impact have been conducted in areas where detergent phosphate bans have been implemented by local jurisdictions. These studies have generally indicated that a substantial number of consumers have made numerous adjustments in their washing habits after the imposition of bans and that these adjustments have added significantly to the costs of home laundering.

One of the earliest studies was conducted by Homemaker Testing Corporation for FMC Corporation, a leading supplier of phosphate compounds.**/ Two cities were selected for comparison -- Kansas City, Kansas, and Indianapolis, Indiana, both of which had about the same water hardness conditions, i.e., both are

*/ Rutkowski, Op. Cit., pp. 3-4.

**/ "Cost of Home Laundry," (October, 1974), Homemaker Testing Corporation (Washington, D.C.).

relatively hard water areas.*/ At the time of the survey (September - October, 1974), phosphate detergents were freely available in Kansas City, but not in Indianapolis which had been subject to a state-wide detergent phosphate prohibition since January 1, 1973. Two hundred in-home interviews were conducted in each city. Detailed information was solicited concerning the amount and frequency of each laundry detergent used and the interviewer recorded all washing products on hand. Laundry habits, such as double washing or extra rinsing, were also determined. The results showed that laundering costs were 41% higher for non-phosphate users than for phosphate users. Sixteen percent more detergent was used and 76% more laundry aids (bleach, softeners, spotters, water conditioners, etc.) were consumed by the non-phosphate detergent users.

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*/ This study has been criticized by the E.P.A., Region V, because while the water hardness levels of the two areas were quite similar at the time of the survey, the average hardness for the year 1974 was somewhat higher for Indianapolis than for Kansas City (261 mg/L v. 219 mg/L) and state-wide, the water hardness ranged up to as high as 344 mg/L for 1974. They concluded that for Indiana those "hard days" may have caused the use of more cleaning materials and thus accounted for the added costs. Detergent Phosphate Ban, Op. Cit., pp. 45-46. However, this criticism does not seem valid because this survey was conducted in Indianapolis (not state-wide) and because the average water hardness is not all that disparate for the two cities. In fact, the Homemaker Testing study pointed out that, in 1973, the average water hardness for Kansas City was 254 ppm, compared to 262 ppm for Indianapolis. The cities were chosen precisely for the reason that they did share very similar water hardness characteristics.

The cost of doing laundry was estimated to be $23.27 per household per year higher in Indianapolis than in Kansas City, just considering the extra detergent and laundry aid consumption. It was also found that 74% of the respondents double washed one or more loads per month and 82% double rinsed one or more loads per month. However, no estimate was made of the energy or machine wear costs which might have been engendered as a result.

It is difficult to generalize about costs to an "average" family in these areas because homes with mechanical softeners -- which were being used by one-quarter to one-third of the households in Indianapolis -- were excluded from the survey. In these hard water areas, water softeners would act to diminish somewhat the pronounced performance differentials between phosphate detergents and their alternatives. However, to the extent that mechanical water softeners are installed to reduce the poorer cleaning capacity of non-phosphate detergents in ban areas, their costs (or some portion of their costs) should be properly attributed as a cost of the ban.

Because homes with water softeners were not included, because both cities were hard water areas where phosphate cleaning products tend to be even more efficacious, because only homes using non-phosphate detergents were interviewed in the ban area, and only households using phosphate detergents in the non-ban area, the Homemaker Testing results cannot be applied as typical for a household, except to say they form upper-bound estimates on the kinds of costs considered.*/ However, the survey does provide insight into the presence and direction of the sort of costs created by phosphate bans, if not fully on the order of their magnitude for the average household.

In 1973, Homemaker Testing conducted a study in Indiana**/ and Erie County, New York,***/ again both for FMC, to obtain an appraisal of homemakers' attitudes toward the phosphate detergent bans. Both surveys indicated a high level of consumer dissatisfaction with the cleaning qualities of the detergents they were then using and an awareness of the additional costs they seemed to be incurring (even though a large percentage did not realize they were using non-phosphate products).

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*/ The E.P.A., Region V, further criticized the survey for not comparing the age differences of children and the profession of the adults, which might account for dirtier clothes in one area or the other, the size of washload, and whether top-loading or front-loading washers were used, the iron content of the water in both areas, and the pH balance. Detergent Phosphate Ban, Op. Cit., pp. 47 and 50. These would have to be regarded as minor factors, not significantly detracting from the survey results. In fact the survey did choose families in the two cities which had similar characteristics regarding age and educational levels, numbers and ages of children, and family income levels.

**/ "Detergent Study of Indiana," (November, 1973), Homemaker Testing Corporation (Washington, D.C.).

***/ "Study, Detergent Phosphate Ban, Erie County, New York," (May 1-10, 1973), Homemaker Testing Corporation (Washington, D.C.), Erie County had been subject to a ban since January 1, 1972.

Walker Research, Inc., was commissioned by The Soap and Detergent Association to conduct a consumer research project in March, 1976 designed to determine if female heads of households in Indiana "experienced or perceived having experienced changes in their laundry habits" as a result of the phosphate ban which was then in effect in Indiana (since January 1, 1973).*/ Using random sample methodology, about 1,500 completed interviews were obtained in five Indiana cities among women who did their family's laundry prior to the phosphate ban. Thirty-three percent of the respondents indicated that they had made some change in their laundry habits because their detergents no longer contain phosphates. Those respondents who experienced changes generally tended to have increased their use of specific products. The following table shows the order and size of the increases and decreases in specific categories:

(Base) **/		More	Less	Same
(1147)	Pretreating	51%	8%	41%
(1046)	Additives	44%	14%	42%
(895)	Pre-Soak	40%	14%	46%
(1154)	Bleach	36%	9%	55%
(1506)	Detergent	36%	14%	50%
(1088)	Fabric Softener	25%	7%	68%

*/ "Phosphate Detergent Ban Effect on Indiana Housewives," W.R. #199-02 (1976), Walker Research, Inc. (Morristown, New Jersey).

**/ The base for each category represents those women who reported usage of the category, thereby excluding those women who were interviewed but who did not use the particular products in question.

The substantial increase in the use of pretreatment products, additives, pre-soaks, bleach and detergent is striking. Another interesting result of the survey was that 13% of all respondents indicated that they had used out-of-state detergents over the past three years and that 5% were then using such detergents. Though a part of this could be due just to the normal shopping patterns of residents living close to state borders,*/ there did appear to be a significant amount of "bootlegging" going on.**/ The Walker survey also pointed out that about 5% of the respondents who had a water softener device indicated that they had installed it explicitly because of the ban on phosphate detergents.

Walker's conclusion that 33% of the respondents had made changes in their washing habits because of a ban is in line with the results of a survey in Erie County, New York (a ban area) in 1973 by Professor Howard Hammerman of Cornell University.***/

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*/ Many of the respondents using out-of-state detergents did not live in cities located in close proximity to state boundaries. Also, in the Homemaker Testing study of Indiana in 1973 (on p. 35 of their report), 161 of the 1,680 women approached (or 8.7%) could not be used in the interviews because they used only phosphate detergents, which were banned by the state at the time of the interviews.

**/ The S.D.A. cautioned at the time that these results probably understated the true amount of "bootlegging" because people were disinclined to admit that they were not complying with the spirit of the law.

***/ Howard Hammerman, et al., "The Erie County Phosphate Ban," (June, 1973), Dept. of Urban Planning and Development, Cornell University, Ithaca, New York. Another study by a Dr. William Eberly showed that 30% of the respondents in an Indiana survey were not satisfied with their detergents. U.S. E.P.A. Detergent Phosphate Ban, Op. Cit., p. 60.

He found "only" 28% of the 362 respondents to his survey were "very dissatisfied" or "somewhat dissatisfied."*/ Forty percent of the sample with large families were dissatisfied. He concluded that:**/

> There are some cleaning disadvantages associated with using the non-phosphate detergents. Some of the respondents complained of "gray clothes" or excessive "scum."

A study was conducted in Minnesota in 1977 and 1978 by the Agricultural Extension Service of the University of Minnesota,***/ when nearly all of the detergents sold were non-phosphate products.****/ The first part of the survey was conducted in April and May, 1977 of a small sample of 200 households selected randomly in the Minneapolis-St. Paul metropolitan area. A year

*/ This did not include the percentage of responses which were "somewhat satisfied," which cannot be disaggregated from the "very satisfied" responses.

**/ Howard Hammerman, "Going Along," Human Ecology Forum, (Spring, 1974), p. 27. He found Erie County residents overwhelmingly in favor of the ban, which is probably predictable in light of the question which was asked: "Scientists have reported that the phosphate pollution in Erie County streams has decreased since the switch to non-phosphate detergents. All things considered, how do you feel about non-phosphate detergents in Erie County?"

***/ "Results of a Consumer Perception Survey on Laundry Procedures and Results," Speech to the 29th National Home Appliance Conference, Denver, Colorado, November 10, 1978 (mimeo).

****/ Minnesota's ban was enjoined by a court in January, 1977 pending the outcome of a suit (now settled), but virtually all of the detergent products sold there had already been switched to non-phosphate in anticipation of the ban.

later a follow-up survey was conducted with 102 of the original respondents. In the 1977 survey, 23.7% of the respondents indicated that they had had problems with their laundry; by 1978, 40% were reporting problems. The causes cited included the detergents, water, fibers, machines, and special activities (e.g., football). Awareness that the products were non-phosphate was "not a factor significantly related to perceived problems," but only 40% knew the products were non-phosphate (true in both surveys).*/ The amount of detergent did not change, but the percent of people using bleach and pre-soaks increased dramatically:**/

Percentage of Respondents Using Bleach or Pre-Soaks

	1976 (by recall)	1977	1978
Bleach	64%	73.5%	80%
Pre-Soaks	20%	27.5%	55%

The Procter & Gamble Company (P & G) conducted a study in 1975 which compared the costs per household for detergent and laundry aids in Indianapolis before and after the implementation of a ban to a demographically similar area in Ohio with no ban in effect, comprising Cincinnati, Dayton and Columbus.

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*/ Olson, "Results of a Consumer Perception Survey," Op. Cit., p. 4.

**/ Some of these adjustments may have been related to the reduced use of water at the "hot" setting in the wash water during the period (see p. 4 of Olson Report). However, this appears to have been more than offset by an even greater reduction in the use of water at the "cold" setting. Median loads washed in "warm" water (which presumably reflects both of these changes) rose from 3.7 per week to 5.8, an increase of 57%.

The estimates were based on data obtained from S.A.M.I.*/ showing the dollar and case sales in the following laundry product categories -- detergents, liquid bleaches, dry bleaches, fabric softeners and water conditioners. Data for both areas were purchased for a five year period (1971-1975) so that there was a two year base period prior to the implementation of the Indiana ban and three years of post-ban data to measure sales trends.

The data for 1971 and 1972 formed the base period for both areas (i.e., equal to 100) and then the case movement for each year -- 1973, 1974 and 1975 -- was computed and compared to the base period. The <u>rate of change</u> was measured for the two areas and compared, as shown in the following example:

	1971-1972 Base	1975
Indiana	100	115
Ohio	100	110
		+ 5 Change

*/ S.A.M.I., or Selling-Areas Marketing, Inc. (a subsidiary of Time, Inc.), is one of the major and most authoritative data gathering companies reporting sales of consumer products sold through grocery stores. Its data are widely purchased and relied upon by companies producing and selling consumer grocery products. Because its raw data are based on warehouse withdrawals of participating stores (which include most, but not all, grocery chains in the country), adjustments were made to its data, as specified by S.A.M.I., so as to capture sales by non-participating stores in the affected areas. The resulting data, which was used in the P&G analysis, was an estimate of total sales for the areas involved for the relevant products.

By using Ohio data, which reflects similar population characteristics, P & G sought to control for "normal" changes in laundering practices which might have occurred in the absence of a phosphate ban. By indexing the later data to the pre-ban period for each area, the company attempted to control the water hardness variable, so that only the effect on laundry practices in Indiana of the detergent phosphate prohibition would be accounted for.*/

The data showed that the sales of detergent and laundering aids increased at a much faster rate in the ban area than in the non-ban area as follows:

Net Differences in Laundering Cost Increases Per Household -- Indianapolis versus Cincinnati, Dayton, Columbus

	1973	1974	1975
Detergents	$ .14	$1.01	$1.67
Liquid Bleach	.14	.36	.48
Dry Bleach	.11	.19	.32
Fabric Softener	.09	.82	1.54
Water Conditioner	.13	.15	.16
Total Net Increase	$ .61	$2.53	$4.17

*/ The E.P.A., Region V, criticized the P&G study because of the water hardness differences between Indianapolis (a hard water area) and the Ohio cities (which have much softer water). Detergent Phosphate Ban, Op. Cit., pp. 45-47. The E.P.A. was incorrect on this point because the Ohio data was used only to eliminate the effects of changes in laundering habits over time. By indexing to the prior period in Indianapolis, only changes in the use of detergents and laundry aids in Indianapolis after the ban were shown. However, water hardness considerations may still apply to the extent that residents of softer water areas (if faced with a ban) may not make changes in washing practices to the same degree as did residents of harder water areas like Indianapolis. The E.P.A. faulted the P&G study for comparing "urban residences (three big cities of Ohio) and a general population, including both urban and rural residents" (p. 47). This too was incorrect because the study compared an urban population (Indianapolis) with an urban population in Ohio.

P & G recently performed another analysis (reported in October, 1979) on information it received from a national brand usage study. The data was collected by an independent survey company, Data Group, Inc., located in Elkins Park, Pennsylvania, from nationwide telephone surveys of 2,750 homemakers from July, 1977 to June, 1978. The respondents were selected randomly from lists of telephone numbers (including unlisted numbers) and the interviews were conducted throughout the year on a continuous basis, thereby eliminating the possible effects of seasonal variations. The data made it possible to compare the laundry experience of 500 respondents in areas with phosphate bans to those of 2,250 in non-ban areas.*/ The methodology of this study is especially useful for our purposes because it examines the problem on a national basis, avoiding the problems of trying to extrapolate results obtained for specific geographic areas.

The study revealed differential effects in four different areas of laundering: (1) use of hot water, (2) use of bleach, (3) use of fabric softeners, and (4) use of pretreatment products. It was found that respondents in ban areas consumed greater amounts of hot water, as follows:

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*/ Statistically, in this survey, over 100 responses in any subgrouping, in this case area, would make the subgrouping acceptable as being representative.

Percentage of Washloads Grouped by Wash Water Temperature

	Wash Water Temperature			
	Hot	Warm	Cold	Total
Non-Phosphate Areas	27%	53%	20%	100%
Phosphate Areas	22%	51%	27%	100%

Percentage of Washloads Grouped by Rinse Water Temperature

	Rinse Water Temperature		
	Hot/Warm	Cold	Total
Non-Phosphate Areas	43%	57%	100%
Phosphate Areas	37%	63%	100%

Based on Department of Energy (D.O.E.) data estimating that the average "cold" setting (groundwater temperature) is 50° F., that the temperature rise in a water heater is 90° F. to produce an average "hot" washer setting of 140° F., and that heating one gallon of water to 90° F. requires .24452 kilowatt hours (KWH),*/ estimates could be made of the added costs to homemakers in ban areas. P & G determined from a national study in 1978 that the average family washes 421 loads per year. Using D.O.E. published cost figures,**/ a cost of $9.39 per household to provide the greater amount of hot water was then derived for electric heaters and $3.13 per household for gas heaters. With an

*/ D.O.E. has estimated that heating one gallon of water from 50° F. to 140° F. requires .24452 KWH. Since a "warm" setting is assumed to be 50% cold inlet water and 50% hot, the .24452 KWH per gallon figure is divided by two for that setting.

**/ Estimates of 4.97¢ per KWH for electricity and 36.7¢ per therm or $3.79 per million cubic feet for natural gas was published by D.O.E. (to be effective for use on September 25, 1979) in the Federal Register, Vol. 44, No. 125 (June 27, 1979), pp. 37534-37535.

estimated 40% of water heaters using electricity, and 60% using gas nationally, an average cost of $5.64 per household was determined, due to the greater use of hot water in ban areas.

The apparent reason for the increased use of hot water in areas where phosphate prohibitions are in effect is that washing at lower temperatures would make the problems of washing with non-phosphate detergents more obvious. As one source pointed out, "one characteristic of non-phosphate detergents that is rapidly becoming more important is their poor cold water solubility" and "our data show non-phosphates dissolve more slowly than do phosphate built products."*/

The P & G study also revealed that homemakers in ban areas used bleach in 33% of their wash loads compared to 26% in areas permitting phosphate use. Calculations used an estimate of 5.8 oz. (about a cup) of liquid bleach or 1/2 cup of dry bleach per load, the prevailing price of Clorox in Cincinnati, Ohio (about $0.90 per gallon) and a conservative estimate of the cost of dry bleach (about $1.50 per 61 oz. box). Assuming about two-thirds of the bleached loads used liquid bleach and one-third used dry bleach, this results in an average weighted cost of $0.0586 per load. Using an estimate of an average of 8.1 loads per week, the cost of bleach used in ban areas was calculated

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*/ Rutkowski, March 22, 1978, Op. Cit., p. 3.

to be $8.15 per household and, in non-ban areas, $6.42 per household. The difference of $1.73 per household was assumed to be due to the presence of the ban.

Similar calculations were made for fabric softeners and pretreatment products. For fabric softeners, the study found that survey respondents in non-phosphate regions used softeners with 72% of their loads versus 67% in other areas. Using an estimate of an average amount per load for Downy (liquid) and Bounce (sheet), a usage breakdown for liquid and sheet softeners and the 8.1 loads per week estimate, it was calculated that added cost for softeners was $1.69 per year per household. For pretreatment products, the survey showed homemakers pretreating laundry thirteen times a year more in ban areas than in other places. Using a cost estimate of pretreatments of about 2¢ per treatment (using a range of prices of $1.00 to $1.29 per pretreatment product and fifty uses per package), it was determined that this added cost was about 26¢ per year for each household in ban areas.

In summary, the 1979 P & G study showed the following:

Laundering Practices	Added Cost per Household in Ban Areas (Annual)
Hot Water	$5.64
Bleach	1.73
Fabric Softener	1.69
Pretreatment Products	.26
	$9.32

These cost data are expressed in terms of prices as of September, 1979. Although the data gathered in the 1979 study indicated that overall detergent usage was higher in ban areas than in non-ban areas, a detergent usage estimate was not included in the 1979 study since it was felt that the interview respondents "make poor estimates of this factor."*/

None of the studies attempting to quantify the magnitude of consumer costs associated with phosphate bans has been able to estimate that portion of mechanical water softener costs which should be properly ascribed to the implementation of a ban. In harder water areas, where performance differences between phosphate and non-phosphate detergents are accentuated, an alternative to improve washing performance with non-phosphate products is to install a mechanical water softener. There is little doubt that some consumers have installed these devices explicitly because of the unavailability of phosphate detergents. For example, the Walker Research Study indicated that 5% of the homemakers surveyed in Indiana had purchased water softeners because their

*/ Letter from Dr. G. G. Cloyd of P&G to Lloyd Oliver, dated November 12, 1979, p. 2. The 1975 Study used actual case shipments of detergents.

detergents no longer contained phosphates.*/ It is also true that water softener manufacturers advertise that the absence of phosphate detergents is one of the reasons to buy a water softening system.**/

The problem in segregating out the portion of costs of mechanical water softeners due to bans is that these devices are installed by homeowners in harder water areas for a variety of reasons, from improving the drinking water to reducing the mineral deposits in plumbing to removing bathtub scum. The poor laundry results (and the reduced washer life and performance and the greater fabric wear associated with carbonate-built detergents discussed below) may be only one of the reasons. Its relative contribution is even more difficult to discern because many people in ban areas are not even aware that they are no longer using phosphate detergents,***/ or that the effects that they are observing are

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*/ Walker Research, Op. Cit., p. 13 (Table 11 of second section of survey).

**/ See, e.g., advertisement by Culligan International in Vincennes Sun - Commercial, Vincennes, Indiana, June 27, 1972.

***/ For example, in the Homemaker Testing interviews in Indianapolis in November, 1973 (nearly two years after the ban went into effect), 38% of the respondents either did not know whether the detergent was different or thought it was not different since the ban. "Detergent Study of Indiana," Op. Cit., p. 6. It will also be recalled that 60% of the people surveyed in Minnesota, well over a year after phosphate products were removed from the shelves, still did not know the products they were buying were non-phosphate. See p. 39 of this paper.

at least partly related to the use of non-phosphate products. For instance, if a homeowner installed a water softener because of perceived problems with a washing machine or plumbing, these problems may be related to use of non-phosphate carbonate-built detergents. Further, the authors have checked and the appropriate data are not available to make even a rough estimate of softener costs properly attributable to a phosphate ban (e.g., a comparison of sales of mechanical softeners before and after a ban went into effect).

Water softening appliances are in widespread use -- one source estimated in 1975 that 8-11% of the population were covered by home water softening.*/ There also seems to be little question that the sales of such devices nationally have been increasing rather importantly.**/ ***/

*/ Statement by Bruce P. Anderson, Executive Vice President, Point-of-Use Water Industries, Inc. (an association of water conditioning contractors) before the Minnesota Pollution Control Agency, April 9, 1975.

**/ Data collected by the Water Quality Association showed a 43-92% increase in physical sales volume of softeners from 1971 to 1978, based on unit shipments of pressure tanks and valves. Reporting companies represented about one-third of the member manufacturers and were generally the largest firms in the industry.

***/ There has been some ecological concern expressed about the increasing use of mechanical water softeners which regenerate with salt (i.e., they use salt to remove the minerals in the water), large amounts of which are discharged into inland waterways.

The installation and use of water softener appliances can be expensive. One report calculated in 1977 that the costs of a water softener appliance may run 6-10 cents per wash load ($25 to $42 per year based on the estimate of 35 loads per month used in the report).*/ The total cost of a water softener, plus operating costs, may currently range between $70 and $205 per year.**/ Some of these costs may be offset by the need to use less laundry products in softened water.

5. OTHER PERFORMANCE PROBLEMS WITH NON-PHOSPHATE CARBONATE-BUILT DETERGENTS.

a. GENERAL.

In addition to problems of comparatively poorer cleaning ability, non-phosphate, carbonate-built detergents have been shown to cause washing machine and fabric damage.

Serious concern has frequently been expressed by the washing machine manufacturers regarding the use of non-phosphate carbonate-built detergents dating back from an early point in the phosphate controversy. In 1971, for example, Whirlpool

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*/ Olson, "Using Non-Phosphate Detergents in Machine Laundry," Op. Cit., p. 1. The report pointed out (footnote 2, p. 1): "Costs of softening water for laundry are actually twice the total per gallon cost since only half the household water is used in ways which benefit from softening such as laundry, dishwashing, and cleaning."

**/ "The Economic Impact of Phosphate Laundry Detergent Bans on Consumers," The Soap and Detergent Association, January 3, 1980, p. 11.

(which also supplies the Kenmore washers to Sears, Roebuck and Co.) was warning in a booklet packed with washing machines sold under its own name that in water of the hardness that is supplied to two-thirds of the population, phosphate-free carbonate-built detergents leave "a scaly build-up" that can interfere with the operation of the machine's pump, agitator and filter and "can cause abrasion or wear of clothes as they rub against the agitator and tub."*/

Whirlpool, General Electric, the Speed Queen Division of McGraw-Edison, and the Frigidaire Division of General Motors, among others, have appeared at local hearings and testified against the imposition of phosphate bans.**/ This testimony has been directed not only to the inferior washing quality of the non-phosphate carbonate-built products but to shortened washer life, greater incidence of repair, reduced operational efficiency

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*/ Fortune, Op. Cit., p. 168.

**/ Testimony by Donald M. Schultz, Supervisor of Domestic Laundry Equipment and Director of Service Publications, Speed Queen, to the Committee on National Resources and Tourism, State of Michigan (February, 1978); statement by Beverly J. Rutkowski, Senior Research Chemist, Science Research Department, Whirlpool Corporation, to the Michigan National Resources Commission, December 8, 1976 and testimony to the Energy and Environment Committee, Ohio House of Representatives, March 15, 1978; testimony by M. Ross of Frigidaire to Energy and Environment Committee, Ohio House of Representatives, March 15, 1978; and statement by Robert Shuck, Chemist, Laundering Fundamentals, Physical Sciences Laboratory, General Electric, presented at the Minnesota Pollution Control Agency, February 12, 1975.

and greater fabric wear associated with their use. The opposition of these manufacturers alone is significant, if for no other reason than none of them sell phosphate detergents or their ingredients, or otherwise stand to gain by the continued sales of phosphate detergents.

b. WASHING MACHINE DAMAGE.

The manufacturers have conducted some investigation into the effects of using non-phosphate carbonate-built products on their machines. The Supervisor of Service Publications and Supervisor of Domestic Laundry Equipment of Speed Queen performed a telephone poll in 1977 of five different independent service companies in Dade County, Florida; Indianapolis, Indiana; Minneapolis, Minnesota and Saginaw, Michigan (all ban or *de facto* ban areas of from one to three years at the time). He found: (1) Service calls increased 15% to 20% after the ban; (2) about 20% of the service calls were for "poor washability" rather than mechanical problems; and (3) machine part life was reduced 15% to 20% after the ban, with certain parts like center posts having up to a 30% to 40% reduction.*/ The replacement cost price (parts only) for a tub was estimated to be $89, a center post - $17.50, an agitator - $13.50, and a pump - $17.50. Service calls for labor only were calculated as being $19 to $20 on average nationally.**/

*/ Testimony by Donald Schultz of Speed Queen, *Op. Cit.*, p. 1.

**/ *Ibid.*, p. 1.

General Electric Company (G.E.) also conducted a survey of service expenses which compared Indianapolis, a ban area, with certain other cities in non-ban areas and found that consumers' service expenses were 50% higher in the ban city.*/ Another study was made by G.E. of the number and types of service calls requested by non-commercial owners of G.E. washers who purchased formal service contracts in Indianapolis as compared to Columbus, Ohio, a non-ban area.**/ The study, which covered a full year from mid-1975 to mid-1976, looked at service calls on a large number of machines in each city (350-400) which were of a similar age/exposure mix (2-4 years old). It found that the service call rate in Indianapolis was 10.1% higher than in Columbus. A little more than half of the increase was due to consumer education calls -- e.g., problem diagnosis and advice on how to prevent complaints such as "poor washability," "stains" and "poor rinsing." The consumer education calls are probably one-time-only calls which may be expected to diminish somewhat as consumers adjust to having to use non-phosphate products. The remaining calls, however, dealt with the mechanical operation of the machine, which should be regarded as recurrent,

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*/ Testimony by Robert Shuck in Ohio, Op. Cit.

**/ Letter from Robert F. O'Grady, Manager, Product Service, Home Laundry Marketing Operation, General Electric Company, to A. J. Fuchs of P&G, August 23, 1975.

suggesting greater machine problems in ban areas on a continuing basis, although differences in water hardness levels between the two cities may have accounted for some of the differential effects observed.*/

G.E. also performed an analysis in 1973 or 1974 of coin-operated machines in Indianapolis and found a serious problem with pump failures due to the abrasion of the pump seal by calcium carbonate particles, so that after fourteen months of use the pump outlets almost totally clogged with lime and lint scale.**/ The washers were apparently using exclusively a carbonate-based detergent. The company pointed out:***/

> Extrapolating from the experience with these coin-operated machines, it would appear that automatic washers in normal home usage in the Indianapolis metropolitan area might be expected to have a useful operating life of 3-4 years, or possibly less, depending upon usage patterns. This would be considerably below the average useful life of automatic washers in areas in which phosphate detergents are permitted.

G.E. observed that in a softer water area (e.g., Michigan), the useful life of an automatic washer might be shortened to

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*/ Columbus, Ohio is a softer water area than Indianapolis.

**/ "Carbonate Detergents and Their Effect Upon Clothing and Home Laundry Equipment," Op. Cit., p. 3.

***/ Ibid., p. 3.

eight years.*/

Table II shows the average value at retail for a clothes washer in 1978 to be about $369. Based on an average life of a washer nationally, which is thought to be about ten to eleven years,**/ the G.E. data imply a quite substantial reduction in machine life, and therefore a significant consumer cost. The G. E. results probably overstate the effects on consumer washing machine costs, since their tests appear to have been performed with a detergent high in carbonate content, which is not generally used today.

Thus, the available research on washing machines indicates that low phosphate, high carbonate detergents result in adverse effects on washing machine parts and on machine life, and, therefore, represent an additional cost to consumers using such detergents.

c. FABRIC DAMAGE EFFECTS.

A number of experiments have been conducted of the effects on washable fabrics due to the use of non-phosphate, carbonate-built detergents.***/ G.E. performed tests on 100% cotton

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*/ Results cited by Joy Schrage, Manager, Consumer Assurance Home Economics, Whirlpool Corp., in a letter to Thomas J. Anderson, Representative of the State of Michigan, February 25, 1977.

**/ Source is the Association of Home Appliance Manufacturers.

***/ Other non-phosphate detergents "have not been shown to contribute to fabric damage." "The Economic Impact of Phosphate Laundry Detergent Bans on Consumers," S.D.A., Op. Cit., p. 8.

TABLE II

AVERAGE VALUE OF CLOTHES WASHERS, 1978

1978	Unit Shipments millions	Retail Value $ millions
Clothes Washers	4.990	$1,881
Clothes Washers, compact	.288	66
	5.278	$1,947

Average Value	
Clothes Washers	$377
Clothes Washers, compact	$229
Clothes Washers, total	$369

Source: Appliance Manufacturer: Profile of the Appliance Industry (Cahners Publishing Co., Chicago, 1978) p. 380. According to the editors of Appliance Manufacturer the data sources for appliance shipments and retail value represent exclusive Appliance Manufacturer material derived by market trade surveys, confidential reports, and other proprietary information.

shirting fabric in multiple washings using 70% sodium carbonate detergent in water of 128 ppm hardness.*/ From these tests, it was concluded that there could be a reduction of "as much as 15% in the service life of garments, depending on wash conditions and fabric types" and that additional tests suggested that fabric degradation could be more severe, implying a possible 20% reduction in the useful life of a garment.**/

Another study conducted on cotton fabric in 1975 by university researchers under a government contract with a detergent containing 55% sodium carbonate as the builder in a water hardness of 300 ppm, found that:***/

> If we assume that the rate of abrasion is linear (this appears valid within the limits of our study) we estimate a 25-30% reduction in wear life due to the use of carbonate detergents under hard water (300 ppm) conditions. It seems safe to assume that deposits on the laundering equipment would lead to even greater reduction in wear life.

The principal effect on clothing appears in harder water with carbonate detergent. However, an effect is indicated

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*/ "Carbonate Detergents and Their Effect," Op. Cit., p. 2.

**/ Ibid., p. 3.

***/ Letter to Dr. Keith A. Booman, Technical Director, The Soap and Detergent Association from Harriett H. Prato, Staff Research Associate, Department of Consumer Services, University of California, Davis, dated October 31, 1978. Based on research published by Ms. Prato and Mary Ann Morris in "Fabric Damage During Laundering," California Agriculture Vol. 30, December, 1976, p. 9 and "Edge Abrasion of Durable-Press Cotton Fabric During Laundering with Phosphate and Carbonate-Built Detergents," Textile Research Journal, May, 1975, pp. 395-401.

to occur in softer water as well (see our earlier discussion of water hardness) and to increase as the carbonate content is increased and greater water hardness is encountered. The two tests discussed above used high carbonate detergent (70% and 55% carbonate), harder water (128 ppm and 300 ppm) and cotton fabric, which appears to be somewhat more susceptible to carbonate build-up. These conditions probably acted to overstate the results of the tests, but we still should expect some significantly increased fabric wear in ban areas for several reasons. Carbonate-built detergents still constitute the lion's share of household detergents sold in ban areas (compared to only a small share in non-ban areas),*/ though the carbonate content probably now only ranges between 20% to 50%.**/ Cotton remains the principal fiber (often in combination with others) laundered in households and studies have shown residue build-up on other commonly used fabrics as well, specifically acrylics and nylon, by using carbonate detergents.***/

*/ See p. 28 of this report.

**/ Detergent Phosphate Ban, Op. Cit., p. 58, footnote **. The S.D.A. points out that 25% sodium carbonate content is typical for a majority of the non-phosphate detergents on the market today. "Economic Impact of Phosphate Laundry Detergent Bans on Consumers," January 3, 1980, Op. Cit., p. 7.

***/ Whirlpool research has found significant residue build-up on polyester/cotton blends with carbonate detergent after just ten washings in hard water and a lesser build-up on acrylic fabrics. The build-up appeared on both fabric types with as little as 3% carbonate content in the detergent. Rutkowski, Op. Cit., Table 8. Further, the University of California study determined that, "A heavy build-up of calcium deposit was found on both cotton and nylon fabrics laundered in hard water with carbonate detergent and builder." Morris and Prato, "Fabric Damage During Laundering," Op. Cit. (Emphasis supplied).

Further, most of the population of the United States, 64% according to Table I (see page 30), reside in areas with "medium hard" to "very hard" water (over 60 ppm).

Other fabric effects, such as fading of colors, grayness in white clothing, and harshness have also been cited.*/

While it is difficult to measure specifically the fabric damage which does result from the use of carbonate-built detergents, the existing information indicates that these adverse effects do occur. Table III shows the items which we estimate are probably washed in the home, based on the most recent Consumer Expenditure Survey data published by the Department of Labor. Adjusting for price increases, annual expenditures for washable clothing and washable household textiles per family as of June, 1980 was about $445.11 (Table IV). It is clear that even a small reduction in the wear life of these fabrics could result in substantially increased consumer costs.

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*/ For example, see testimony by Kathleen Strawhacker, Manager of Consumer Affairs, Speed Queen, in hearings in the State of Wisconsin (undated) (mimeo).

TABLE III

AVERAGE ANNUAL FAMILY EXPENDITURES IN 1972 - 1973
FOR CLOTHING AND HOUSEHOLD TEXTILES

Category	Amount Spent in 1973	Majority of Category Assumed Washable	Non-Washable
I. Clothing			
Coats	$ 33.35		X
Jackets	12.87	X	
Sweaters & sweater sets	10.04	X	
Snow suits, plastic raincoats & fur coats	6.63		X
Suits, sport coats & vests	42.90		X
Trousers or slacks	38.16	X	
Work or short pants	10.20	X	
Swimsuits & other sports-wear	6.47	X	
Uniforms & special work clothes	4.69	X	
Shirts	28.62	X	
Underwear	26.64	X	
Nightwear & Loungewear	12.91	X	
Hoisery	27.28	X	
Casual & dress shoes, & sandals	56.83		X
Sneakers, gym & sport shoes	8.09	X	
Boots, slippers & other footwear	15.30		X
Hats, caps & helmets	1.96		X
Gloves & mittens	2.52	X	
Jewelry & other accessories	38.79		X
Dresses	49.85	X	
Suits & ensembles	29.29		X
Blouses & shirts	22.36	X	
Skirts, culottes, slacks & shorts	32.86	X	
Handbags & purses	5.58		X
Outer wear	2.99	X	
Diapers, disposable	3.41		X
Washable diapers, booties, socks	2.66	X	
Layettes & other */	5.47	X	
Subtotal Clothing	$538.72	$304.68	

TABLE III (Cont'd.)

Category	Amount Spent in 1973	Majority of Category Assumed Washable	Non-Washable
II. Household Textiles			
Sheets & pillowcases	$ 8.14	X	
Pillows & bed spreads	6.01	X	
Electric & other blankets	1.99	X	
Table linens	1.51	X	
Towels, bath curtains & mats	5.20	X	
Curtains & draperies	18.12		X
Slipcovers & other	9.85	X	
Subtotal Household Textiles	$ 50.82	$ 32.70	
TOTAL:	$589.54	$337.38	

*/ Refers to infant clothing, blankets, apparel, etc.

Sources: Consumer Expenditure Survey: Interview Survey, 1972 - 1973, Bureau of Labor Statistics, U.S. Department of Labor, B.L.S. Bulletin #1997, U.S. Government Printing Office, 1978.

TABLE IV

AVERAGE ANNUAL FAMILY EXPENDITURES IN 1972 - 1973 FOR WASHABLE CLOTHING AND FOR WASHABLE HOUSEHOLD TEXTILES, ADJUSTED TO COMPARABLE BASIS AS OF JUNE, 1980

I.	Washable Clothing	
	1972 - 1973	$304.68
	Adjusted to June, 1980	393.49
II.	Washable Household Textiles	
	1972 - 1973	$ 32.70
	Adjusted to June, 1980	51.62
III.	Total Household Washable Fabric	
	1972 - 1973	$337.38
	Adjusted to June, 1980	445.11

Sources: Table III; Price adjustments from CPI Detailed Report, June, 1980, Bureau of Labor Statistics, U.S. Department of Labor, U.S. Government Printing Office: 1980. Prices for 1972 - 1973 assumed to be December, 1973. Washable clothing was adjusted by the change in the C.P.I. (urban wage earners and clerical workers) index for "apparel commodities" while the washable household textiles category was adjusted by the change in the C.P.I. for "textile house furnishings."

6. SUMMARY AND EVALUATION OF CONSUMER COSTS IN BAN AREAS.

One cannot review the studies which have been done of ban areas without concluding that there are substantial costs to consumers caused by the implementation of detergent phosphate prohibitions. These studies have been performed by independent research organizations, by washing machine manufacturers, by the detergent producers and academic researchers. They have examined the problems of using non-phosphate detergents through controlled experiments in laboratories, by examining data in specific areas before and after bans have been inaugurated, and by comparing experience in ban and non-ban areas during the same periods of time. The result is inescapable; currently available non-phosphate detergents simply do not perform nearly as well throughout the range of laundering conditions as do phosphate-built products, thus requiring consumers to make additional laundering expenditures due to adjustments in their laundering procedures and to bear other costs, especially in terms of washing machine deterioration and fabric wear-out.

The consumer costs are diffuse and the increase in any individual cost component tends to be small, and therefore not readily perceived by consumers. Further, it is clear from the studies that many consumers are not even associating their increased costs with the use of non-phosphate detergent products.

These consumer costs occur across water hardness levels,*/ detergent composition, washable fabric types, and types of soil encountered. The costs tend to be greater in hard water areas with the use of carbonate-built products and lower in soft water regions with the use of liquid detergents.

Given the large number of conditions which affect washing performance (see pp. 21-22 of this paper), statistical studies attempting to isolate the effect of one variable on washing performance (detergent type) are exceedingly difficult. Any study which sought to control all of the relevant factors, or even the majority of them, would be extremely expensive and would probably then have only limited meaning when applied to a specific geographic area with dissimilar characteristics. For this reason, many of the studies which have been done have occurred in limited circumstances with limited data. Each is only a fragment in the overall cost picture. Precise estimates are simply not available and our cost calculations will have to reflect the limitations of the data available to us.

It is against this background that we will try to evaluate the findings of studies generally. The latest P & G data provide us with a basis for estimating consumer costs in certain key

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*/ A recent P & G study, utilizing data from two different surveys (reflecting consumer experience in soft water areas with bans and without bans), indicated that the consumer costs just for extra hot water, bleach and fabric softener in soft water areas subject to phosphate prohibitions were $4.29 per household annually. Letter from Dr. G. G. Cloyd, P & G, to Donald Garfinkel, State Water Control Board, Northern Virginia Regional Office, dated November 6, 1980. Because the study was released immediately prior to the publication of this report, the authors were not able to review fully its findings.

areas. The additional cost of $5.64 per household per year for the extra energy consumed due to the increased use of hot water in ban areas appears to be a relatively sound number. It is based on a recent random probability sample of a representative number of families across the country. As a national average, it looks only to objective differences and abstracts from considerations of water hardness, types of detergent and other variable washing conditions. Further, the data are based on recent Department of Energy cost estimates (for September, 1979). As with all energy costs, this cost can be expected to increase importantly in the coming years.*/

P & G's estimate of $3.68 per household for the added costs of bleach, fabric softener and pretreatment in 1979 (page 45 of this paper) may be overstated to some extent because of using the prices of leading products for its cost estimates. But even if we assume that the prices of all of these products bought by consumers were 15% less than

*/ There is a reason to believe that this cost element may actually increase more than energy costs generally. Regulations are currently being promulgated by the Federal Trade Commission and the Department of Energy seeking to implement a congressionally mandated program of energy conservation for home appliances, including washing machines. It is anticipated that one result of these rules will be an average reduction in water temperature for automatic washers, which would serve to accentuate the poorer washing performance of non-phosphate detergents. This may actually lead to more rewashing and rerinsing, which on balance would probably tend to increase washing energy costs in ban areas.

prices used by P & G,*/ this still provides an additional expenditure of $3.13 annually by ban households as of September, 1979.

The recent P & G study did not make an estimate of increased detergent or packaged water conditioner usage. The company's earlier study (in Indianapolis), however, showed $1.83 for extra detergent and conditioner use in 1975 dollars (see page 41 of this paper). These estimates may contain some overstatement for the purposes of a national average because they essentially measured the differential effect of what occurred in a harder water area after the imposition of a ban. Detergent and packaged water conditioner usage appear to increase proportionately to water hardness, so that a softer water region may not encounter the full extent of the cost estimated by P & G for Indianapolis. The national average water hardness is probably half that of Indianapolis, implying a household cost nationally of about $0.92 per year in ban areas in 1975.

Therefore, just considering the following elements, our rough estimate is $11.10 per household per year nationally, adjusted to June, 1980:

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*/ This estimate is based on the authors' general familiarity with the price structure in the product markets involved. Although the price differentials for the leading brands used in the P & G study and other brands available to consumers, such as store brands, might be somewhat greater, the overall differential should be in the neighborhood of 5-15% due to the greater relative volume of the major brands (i.e., if prices were weighted by brand case sales).

Components of Cost Estimate
(Annual Cost Per Household Nationally)

Item	Original Data	Date of Information	Adjusted to June, 1980 */
Extra Energy	$5.64	9/79	$6.45
Extra Bleach, Fabric Softener, and Pretreatment Products	3.13	9/79	3.36
Extra Detergent and Packaged Water Conditioner	0.92	1975	1.29
TOTAL			$11.10

To this estimate must be added the additional costs associated with washing machine service calls, repair and replacement and fabric wear-out, both of which are primarily related to the use of carbonate-built detergents, and the greater installation of water softener appliances attributable to phosphate bans. Because the data were not available or because the studies dealing with these kinds of expenditures have been conducted under specialized conditions, we cannot estimate the appropriate costs on a national level. However, it is clear that these kinds of costs are real in ban areas and that their proper measurement could increase the consumer cost estimates substantially.

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*/ Energy costs were adjusted by the change in the C.P.I. (urban wage earners and clerical workers) for "fuels and other utilities - gas (piped) and electricity" from September, 1979 to June, 1980 (14.3%); bleach, fabric softener and pretreatment products by the C.P.I. increase for "other laundry and cleaning products" from September, 1979 to June, 1980 (7.5%); and detergent and packaged water conditioner were adjusted by the C.P.I. change for "soaps and detergents" from December, 1975 to June, 1980 (39.9%), U.S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review, Table 23, May 1976, May 1980 and October 1980.

Despite the assumption of the extra costs discussed in this section, the studies illustrate that a significant portion of households have shown relative dissatisfaction with the overall quality of their wash using non-phosphate detergent products.*/ Grayness in white clothing and the fading of colors found with phosphate substitutes, for example, can only be partially ameliorated by laundry aids. In other words, even though they are making the available adjustments (and bearing other costs) in ban areas, consumers in aggregate must accept a lower overall level of satisfaction with their laundry results using non-phosphate detergents. This implies additional consumer welfare losses which are rightly attributable to phosphate bans, but which are difficult, if not impossible, to measure in dollar terms.

For the purposes of this paper, we will use only the strongest evidence available and make a highly conservative estimate that, on average, recurring consumer costs of a phosphate ban are about $11.10 per household per year. Again, this estimate considers only the incremental use of hot water, detergent and additives.

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*/ P & G tabulated several thousand unsolicited consumer comments received on its granular laundry detergents for the years 1977 through 1979. The results showed that complaints outnumbered testimonials for its products in ban areas by a 9 to 1 ratio. In non-ban areas where phosphate products are sold, testimonials outnumbered complaints by 2 to 1. Conversation between Lloyd Oliver and Dr. G. G. Cloyd of P & G.

B. PRODUCER COSTS.

Although there are no studies on the costs to the producers of detergents and detergent inputs due to phosphate bans, it is evident that such costs exist. Detergent manufacturers have had to conduct considerable testing and research on phosphate substitutes, not only on whether the replacement can clean clothing adequately with a minimum of adverse side effects, but also on whether the products will affect human health or safety*/ or the environment. To these costs would be added possible new product introduction and marketing costs and the production and inventory costs of producing and carrying a greater line of brands or the same brands with varying levels of phosphorus content. These costs could easily run into the millions of dollars for the larger manufacturers.**/

The situation of the producers of the ingredient most affected by the bans -- sodium tripolyphosphate (STPP) -- is obviously precarious, since about 90% of all STPP is used as

*/ Many of the products brought out in the wake of the anti-phosphate fever of the early 1970's were shown to cause severe eye and skin irritation and to remove the flame retardancy of cotton fabrics. In one instance, 1,000 cases of a popular non-phosphate detergent were seized by the F.D.A. after tests showed that it was toxic and corrosive to the skin and eyes. Steinfeld, Op. Cit., p. 5.

**/ An extreme example in this regard is that P & G reportedly had to write off $7.1 million in binding contracts to purchase NTA, after the government raised its health concern with the builder in 1971. Fortune, Op. Cit., p. 170.

a builder in household laundry detergents.*/ Most STPP produced in the U.S. is derived from elemental phosphorus using a process by which phosphate rock is electrically heated in a reduction furnace to form phosphorus, which is then oxidized and hydrated to phosphoric acid.**/ Phosphoric acid is reacted with soda ash in a kiln to make STPP. In 1976, 84% of all phosphoric acid was made by different means called the "wet process" (where sulfuric acid is applied to phosphate rock), which is especially suitable for fertilizers. "Applications such as detergent phosphates requiring a greater purity use furnace acid."***/ In fact, about 50% of the phosphate production of a furnace plant would go to STPP and only a minor portion of fertilizer phosphate plant would go to STPP manufacture.

The approximate capital cost of a 70,000 ton per year phosphate furnace plant with two furnaces was estimated to be about $50 million in early 1975, excluding land. The additional cost of a plant to convert phosphate rock to phosphoric acid was then thought to be $3.4 million and of a facility to make STPP from the acid, $10 million.****/ Adjusting for

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*/ The Kline Guide to the Chemical Industry, Op. Cit., p. 77.

**/ Ibid., p. 76.

***/ Ibid.

****/ "An Analysis of the Sodium Tripoly Phosphate Business," Butcher & Singer, Op. Cit., pp. 29-31 and 37.

price increases, this would imply about $109 million in capital outlays today to enter the production of STPP.*/

Because of the high capital cost of establishing a plant and the declining demand for STPP due in large part to the imposition of phosphate bans, or the threat of bans, a substantial amount of STPP capacity has been shut down, companies have exited the industry, and no new plants are expected.**/ One source projects that STPP production will decline from 22% to 44% of 1976 levels by 1986.***/

One reason for the shutdown of plants is that the production of STPP is subject to high fixed costs and there are substantial economies in large scale production. Under these circumstances, we should expect higher per unit costs in production in the intermediate term as plants are forced to operate at lower rates of capacity utilization. In the long run, plants can be expected to exit the industry and their

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*/ Based on a 72% rise in U.S. Department of Commerce Construction Cost Index from 1974 to May, 1980. Survey of Current Business, Vol. 60, No. 7 (July, 1980), p. S-9 and Vol. 56, No. 1 (January, 1976), p. S-10.

**/ Butcher & Singer, Op. Cit., p. 13. This report cited an announced plant expansion by FMC, but this never occurred. "No other firm expansion plans appear to exist domestically." (p. 13).

***/ John L. Sherff, "The Outlook for Phosphorus Chemicals," Arthur D. Little, Cambridge Massachusetts (1977), Abstract, p. 10.

resources shifted to less efficient alternative uses.

Curiously, the Region V of the U.S. E.P.A. has postulated that an offsetting "economic benefit" of a ban is that phosphorus is "conserved for food production" (as a fertilizer).*/ This is a questionable argument since: (1) phosphorus occurs widely and is one of the most abundant elements on earth; (2) phosphate detergents are being partly replaced by liquid detergents, which use significantly larger amounts of petroleum (for the production of surfactants) as an input, a product which really is in "short supply;" (3) lower grade ores are used to produce the phosphate consumed in detergent products than for fertilizers; and (4) only about 2% of phosphates processed annually are used in detergents. The conserving of phosphorus and "other chemicals" (*viz*., alum and ferric chloride) cannot be viewed as "economic benefits" in any event. They are presumably being utilized in their most efficient uses, absent external (governmental) intervention in the market allocation system. The justification should not be based on resource "conservation" but on the benefits of dealing with the elimination of the problem which created the need for the intervention. Otherwise, why not just ban the use of platinum in jewelry to preserve platinum?

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*/ *Detergent Phosphate Ban*, *Op*. *Cit*., p. 42.

The "producer" costs discussed in this section cannot be developed with any precision. A significant portion of the more direct producer costs -- such as for research and development, multiple inventorying and production, retooling and product distribution, and marketing -- can be expected to be passed on in the form of higher detergent prices. These costs, together with those attributable to higher short-run input production costs and to the less efficient utilization of resources, constitute real effects of phosphorus prohibitions nonetheless and their implications should be carefully considered before such actions are undertaken, if only qualitatively.

V. CHEMICAL TREATMENT COSTS FOR REMOVING DETERGENT PHOSPHATE.

A. GENERAL.

In a previous section (III., C), it was shown that the appropriate sewage treatment cost factors to consider in an economic evaluation of detergent phosphate bans, are the marginal treatment costs directly related to the removal of detergent phosphorus. The following sections provide a general review of wastewater treatment methods and specifically focus on costs associated with phosphorus removal attributable to detergents. Since the primary objective of this report is to provide a general economic analysis of the costs associated with detergent phosphate bans compared to the costs of detergent phosphorus removal at wastewater treatment plants, no attempt has been made to evaluate the relative efficiency or the cost-effectiveness of different wastewater treatment practices. Rather, the analysis has utilized available information to provide costs representative of generally practical chemical treatment methods, emphasizing wherever possible, the use of current data from actual treatment plant experience. The general methodology used involved: (1) determination of costs to remove all phosphorus present in municipal wastewater to a target effluent concentration of 1 mg/L; (2) determination of the amount of phosphorus in municipal wastewater from detergents; and (3) calculation of the costs to remove detergent phosphorus based on percent contribution to total wastewater phosphorus.

B. NATURE OF CHEMICAL TREATMENT.

There are two basic steps in the treatment of municipal wastewater. The first step, called primary treatment, involves the removal of solid objects from the influent and is achieved by mechanical screening for the removal of large objects, followed by sedimentation. The next step is referred to as secondary (or secondary biological) treatment, the purpose of which is to break down and remove organic materials from the influent.*/

*/ Other methods of treatment, such as land and biological treatment ("luxury" uptake), are discussed later in this report.

Chemical treatment can be easily applied in the variety of treatment plants in existence or being constructed in the U.S. today. It involves the addition of a metal salt, usually an iron or aluminum salt, which reacts with phosphorus present in the wastewater to form a solid that settles out from the wastewater. Most often chemicals are added directly into primary or secondary treatment units. At some plants chemical treatment is added as a final treatment step, so that an additional unit must be added to settle the precipitate. Chemical treatment works because the solids formed by the reaction of the chemicals with phosphorus are similar to the solids wastewater treatment plants are already designed to remove.*/ The amount of the precipitate removed, and which settles into the sludge, can be increased by the addition of a settling agent, or flocculant. Phosphorus removal can be maximized by the addition of another treatment step, filtering, which screens out particulate, or insoluble, forms of phosphate. The addition of this final step can reduce the effluent phosphorus content of treated wastewater to about 0.1 mg/L.**/

*/ Chemical treatment particularly increases the removal of wastes exerting a biological oxygen demand (oxygen demanding organic chemicals).

**/ Baret, Barrios, Groult, Shorrock, Simon and Tournier, A Comparative Assessment of the Effectiveness and Cost of Different Measures Aimed at Reducing the Environmental Impact of Phosphorus in the Surface Waters of Western Europe, Battelle, Geneva Research Centre, July, 1977, p. 91

Although conventional wastewater treatment (i.e., primary and secondary treatment) plants were developed to remove solid and oxygen consuming wastes, the biological and physical processes employed in secondary treatment plants usually result in a considerable reduction of phosphorus as the influent flows through the treatment plant. The phosphorus removal is apparently due either to assimilation by living organisms which settle into the sludge or to the settling out of insoluble phosphorus solids. The average overall phosphorus removal has been estimated to be 20% to 30% at most municipal treatment plants.*/

C. THE COST OF CHEMICAL TREATMENT TO REDUCE EFFLUENT PHOSPHORUS CONCENTRATIONS TO 1 MG/L.

1. COMPONENTS OF COST.

The removal of phosphorus through chemical treatment involves several costs. The most obvious is the expenditure to acquire the necessary chemicals. Second is the capital cost for chemical storage facilities and pumps used to place the chemical into the wastewater. Third, there is the expenditure required to handle the additional sludge generated by chemical treatment. This extra sludge is created not only by the precipitation of phosphorus, but also by the precipitation of other solids present

*/ Elliott, Riding and Sherrard, "Maximizing Phosphorus Removal In Activated Sludge," Water and Sewage Works, March, 1978, p. 88. Baret et al., (p. 75) quote studies indicating as much as 40% of influent phosphorus may be removed in primary settling tanks and as much as 25% may be removed in secondary treatment operations.

in the wastewater.*/ The amount of sludge created can vary depending upon the type of chemical used. The addition of lime, for example, may create six times as much sludge as the addition of ferric chloride or alum, the result of which is to reduce the likelihood that lime will be used.**/ ***/ The exact size of the excess that occurs when lime is used, however, depends largely on the alkalinity of the water. The fourth cost is that of personnel who supervise the operation of the chemical treatment equipment.

2. AVAILABLE COST ESTIMATES.

Some of the cost calculations for reducing phosphorus effluent content to 1 mg/L are presented below:

Annual Cost Per Capita	Source
$4.01 (1.4 MGD to 17.5 MGD ****/)	Michigan Department of Natural Resources (MDNR), Consideration of Municipal Wastewater Treatment for Phosphorus Removal in the Evaluation of a Detergent Phosphorus Ban, August 1976, staff worksheets.

*/ Lee, Rast and Jones, "Eutrophication of Water Bodies: Insights for an Age-old Problem," Environmental Science & Technology, Vol. 12, No. 8, August 1978, p. 903.

**/ N. W. Schmidtke, "Sludge Generation, Handling and Disposal at Phosphorus Control Facilities," 11th Annual Cornell University Conference on Phosphorus Management Strategies for the Great Lakes, April 17-20, 1979, pp. 6 and 12.

***/ Since the dosage of lime is not affected by influent phosphorus concentration in the wastewater, there would be no reduction in phosphorus removal costs from a phosphate ban with lime treatment.

****/ "MGD" refers to millions of gallons per day, or the average amount of wastewater flow processed by the treatment plant.

This figure is the population-weighted average*/ of actual and estimated 1976 costs at four Michigan municipal wastewater treatment plants for phosphorus removal by chemical treatment. The figure includes capital and operation and maintainence costs for both the chemical feed system and sludge handling and disposal. The effluent total phosphorus concentration for these plants in 1976 ranged from 0.7 to 1.1 mg/L with the population weighted average being about 1.1 mg/L.**/ ***/

Annual Cost Per Capita	Source
\$2.49 (1 MGD) \$1.51 (10 MGD)	Baret, et al., A Comparative Assessment of the Effectiveness and Cost of Different Measures Aimed at Reducing the Environmental Impact of Phosphorus in the Surface Waters of Western Europe, Battelle, Geneva Research Centre, July 1977, pp. 101 and 103.

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*/ The population weight used is the actual population served by the plants rather than the population which the plants were designed to serve, which is ordinarily much greater. Use of the latter population data would act to reduce the capital costs per capita used in the estimates.

**/ Remedial Programs Subcommittee, Great Lakes Water Quality Sixth Annual Report, Appendix C, to the Implementation Committee, Great Lakes Water Quality Board, I.J.C., July 1978. The weighted averages were 1.9 mg/L in 1975 and 1.4 mg/L in 1977. Two plants in the M.D.N.R. study were excluded because data on the phosphorus content of the effluent for these plants were not available from the I.J.C. report.

***/ The E.P.A., Region V, also used the M.D.N.R. study to calculate an annual cost of \$3.45 per capita. Detergent Phosphate Ban, Op. Cit., p. 42. Since we were unable to determine how this cost figure was derived, their cost estimate was not used.

The preceding figures (for 1976) include annual capital and operation and maintenance costs (including labor, precipitating chemicals, flocculating chemicals and energy) for both chemical treatment and sludge handling at two plants of different sizes (1 MGD and 10 MGD), achieving an effluent total phosphorus concentration of 1 mg/L. The average total phosphorus content of the secondarily treated wastewater to be subject to chemical treatment was assumed to be 10 mg/L in this European study.

These figures do not include costs for final sludge disposal because they were considered to be "very dependent on the specific local conditions and . . . is generally low compared to other cost items." A breakdown among the various cost components is presented in Table V.

Annual Cost Per Capita	Source
$4.31 (1 MGD, Alum) 4.20 (5 MGD, Alum) 3.65 (1 MGD, Ferric Chloride) 3.47 (5 MGD, Ferric Chloride)	Ciecka, Fabian, Merilatt, and Murphy, An Economic Analysis of Phosphorus Control and Other Aspects of R76-1, contracted for by Institute for Environmental Quality, State of Illinois, June 1978, pp. 21 and 24.

These figures, updated by Ciecka et al. to July, 1977, are the calculated capital and operating and maintenance costs for chemical treatment and chemical sludge handling at plants having flows of 1 and 5 MGD. To determine capital and operating and maintenance costs for the chemical feed system, it was assumed that chemicals would be added to the raw influent sewage to

TABLE V

Chemical Treatment Costs at Municipal Wastewater Treatment Facilities
(Dollars per capita per year)

Chemical Feed System Capital	Chemical Feed System Operating	Sludge Handling and Disposal Capital	Sludge Handling and Disposal Operating	Total Capital	Total Operating	Total Cost	References
$ 0.75	$ 1.49	$ 0.93	$ 0.84	$ 1.68	$ 2.33	$ 4.01	MDNR (4 plants), 1976 (1.4 MGD to 17.5 MGD)
0.31	2.05	0.00	0.12*			2.48	(1 MGD) Baret *et al.*, 1977
	1.43 (Both)	0.00	0.08*			1.51	(10 MGD) Baret *et al.*, 1977
ND	3.14		0.88**	0.29		4.31	(1 MGD, Alum) Ciecka, 1978
ND	3.14		0.88**	0.18		4.20	(5 MGD, Alum) Ciecka, 1978
ND	2.23		1.10**	0.29		3.65	(1 MGD, Ferric Chloride) Ciecka, 1978
ND	2.23		1.10**	0.15		3.47	(5 MGD, Ferric Chloride) Ciecka, 1978
				0.54	1.81	2.35	(6 MGD to 950 MGD) Orynan, 1978

ND Not Determined.
* Excluded ultimate sludge disposal costs.
** Only sludge dewatering costs are included.

achieve an effluent total phosphorus concentration of 1 mg/L. It was further assumed that the influent total phosphorus concentration would be 10 mg/L.

The sludge handling costs used by Ciecka et al. were based on influent total phosphorus concentrations of 10 mg/L also, but the costs covered only chemicals and sludge dewatering. They did not include costs for final disposal because of the sensitivity of those costs to location and disposal methods. See Table V for a breakdown of these figures.

Annual Cost Per Capita	Source
\$2.35 (6 MGD to 950 MGD)	W. R. Drynan, International Joint Commission, International Reference Group on Great Lakes Pollution from Land Use Activities, Relative Costs of Achieving Various Levels of Phosphorus Control at Municipal Wastewater Treatment Plants in the Great Lakes Basin, July 1978, p. 12.

The above figure represents the annual cost differential between treatment plants in the Great Lakes Basin not practicing chemical treatment and those practicing chemical treatment to achieve effluent total phosphorus concentrations of 1 mg/L. It was determined in a computer modeling study of 43 municipal wastewater treatment plants in the Great Lakes Basin, covering both primary and secondary treatment plants. Capital costs and operation and maintenance costs for chemical treatment and sludge handling and disposal were included. Plants used in the study represented a cross section of plants in both the United States and Canada.

From the various studies it is clear that the estimates determined are sensitive to the various assumptions made. The study prepared for the State of Illinois amply illustrates the point. It presents two cost figures for a plant of one million gallons per day. The reasons for the difference between the $3.65 and $4.31 per capita per year estimates is that ferric chloride is used in the first plant and alum in the second. Also, charges for transporting chemicals from suppliers to the treatment plants have a significant impact on the final cost of the chemicals and, therefore, on the determination of the most cost-effective chemical to use.*/

Differences in chemical treatment expenditures can also be due to varying sludge handling and disposal costs. Sludge may be transported by truck, barge, or pipeline. It may be disposed of in landfills, at sea, or incinerated to reduce its volume. The transportation distance and land acquisition costs can vary widely among treatment plants. All these factors can obviously lead to substantial differences in costs. This explains why some studies which attempt to develop costs have restricted the exercise to those expenditures excluding ultimate sludge disposal costs. The available total cost figures for chemical treatment range, therefore, from $1.51 to $4.31 per capita per year.

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*/ Professor Ciecka indicated in a telephone conversation that transportation cost differences were responsible for the cost difference where alum was used in both plants.

For the purposes of this economic analysis, the data developed by the Michigan Department of Natural Resources (M.D.N.R.) were selected for several reasons:

1. The M.D.N.R. and Drynan data were based on removal of phosphorus from actual influent concentrations down to effluent concentrations of 1 mg/L or thereabout (achieving effluent phosphorus concentrations of 0.7 to 1.1 mg/L in 1976). Both the Baret and Ciecka figures were calculated on the basis of assumed phosphorus concentrations (of 10 or 11 mg/L) rather than the actual experience of plants.

2. The Baret and Ciecka figures did not include ultimate sludge disposal costs.

3. The Baret estimates were based on European experiences.

4. The Baret and Ciecka estimates were calculated on the basis of data from other references. The M.D.N.R. data were based on actual capital and operation and maintenance costs for chemical treatment and estimated capital and operation and maintenance costs for sludge handling and disposal. The Drynan figures were based on the use of a computer model that simulated different levels of municipal wastewater treatment, including phosphorus removal, at 43 major municipal facilities in the Lake Erie and Lake Ontario drainage basins.

5. The estimates determined in the Drynan study for the I.J.C., while based on simulated wastewater treatment costs at a much greater number of plants (43), included one plant in Akron, Ohio, and seven plants in New York State where bans on

phosphate detergents existed in 1975, the year the data base was collected. Further, twenty municipal plants included in the study were located in Ontario, Canada, where the phosphorus content of laundry detergents is limited to 2.2% (expressed as elemental phosphorus). Thus, only 15 of the 43 plants included in the Drynan study were located in areas where bans or limitations on phosphate laundry detergents did not exist. The Drynan cost figures, then, would act to underestimate phosphorus removal costs in areas where there are no limitations on the phosphorus content of detergents.

The M.D.N.R. cost figures discussed earlier (for four plants), expressed as dollars per capita per year, adjusted to mid-1980, are as follows:

	Chemical Feed System		Sludge Handling & Disposal		
Year	Capital	O&M */	Capital	O&M */	Total Costs
1976	$0.75	$1.49	$0.93	$0.84	$4.01
1980**/	1.13	2.12	1.40	1.51	6.16

*/ "O&M" means operating and maintenance costs.

**/ These data were adjusted for the period June, 1976 to June, 1980 (May, 1980 for capital costs) using various government indexes. The increase in capital costs was measured by the rise in the U.S. Department of Commerce Construction Cost Index (50%). For the chemical O&M costs, an average of the increase in the producer prices for industrial chemicals and the increase in wages in the transportation and public utility sector was used (42.5%). An average of the increase in fuel costs and wages in the transportation and public utility sector was employed (80%) for sludge handling O&M costs. Survey of Current Business, Bureau of Economic Analysis, U.S. Department of Commerce, Vol. 60, No. 7 (July, 1980) pp. S-7, S-9, and S-14 and Vol. 57, No. 1 (January, 1977), pp. S-9, S-10 and S-16.

These figures will be used in the following sections of this report to determine the costs of chemical treatment attributable to phosphate detergents.

D. THE PROPORTION OF RAW WASTEWATER PHOSPHORUS CONTENT DUE TO LAUNDRY DETERGENTS.

The proportion of phosphorus concentration in influent wastewater which is due to laundry detergents has been variously estimated as follows:

Percent	Source
45 (maximum)	Ronald Waybrant, Michigan Department of Natural Resources, Environmental Protection Bureau, testimony before the Michigan Department of Natural Resources, December 8, 1976, p. 5.
40	Region V Phosphorus Committee, Office of the Regional Administrator, Region 5, United States Environmental Protection Agency, Detergent Phosphate Ban, June 1977, p. 29.
21	The Soap and Detergent Association, "The Impact of Phosphate Laundry Detergent Bans on: I. Wastewater Treatment, II. Water Quality," January 3, 1980, Tables III and IV.

Data are not available to support the 45% "maximum" presented in the Michigan hearings. It may be that isolated plants could be found where this reduction occurs, but a maximum, of course, tells us nothing about averages and cannot be used in a cost calculation.

The Region V Phosphorus Committee study presented data to support the 40% calculation. These data summarize influent phosphorus concentration changes that occurred at municipal wastewater treatment plants in Erie and Monroe Counties, New York, Chicago, Illinois, and Indiana after the implementation of phosphate detergent bans. Average influent phosphorus concentration reductions between 48% and 63% were reported to occur in the Indiana and New York plants cited. Data on three wastewater treatment plants in the Chicago area were presented. The Region V report states that, "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 ..." (p. 52), and concludes that data on the third plant (West-Southwest) do "not allow us to accurately estimate what portion of the phosphorus reduction is attributable to the phosphorus ban ..." (p. 55). The report then compares 1969-1970 (pre-ban) data with 1972 (post-ban) data. The data show (p. 55):

	MG/L of Phosphorus in Influent	
	Calumet	North Side
1969-1970	9.2	10.2
1972	7.9	4.9
Percent Change	-14%	-52%

The average of these reductions in phosphorus concentration observed at the two plants is 33%. The 1969-71 period, however, was one where the phosphorus content of detergents was about 9% to 12%.*/ A change from this level to 0.5% or less (permitted in ban areas) is obviously far greater than a change from 5.5-6.0% (the present level) to 0.5% or less and, therefore, may account for the high percentage influent phosphorus concentration reductions that were observed in Chicago. The same can be said of the percentage reductions that were recorded in Indiana and New York where bans went into effect in December 1972 and June 1973, respectively.

The 21% figure presented by the S.D.A. is supported by data comparing the pre- and post-ban influent phosphorus concentrations for 57 Michigan and 20 Minnesota municipal wastewater treatment plants. For the Michigan plants, a one year period before the ban (July, 1976 to June, 1977) was used to measure phosphorus influent concentrations; these were compared to the concentrations for a one year period (January-December, 1978) after the ban.

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*/ See page 6 of this report.

An average 19% decrease was observed. In Minnesota, a similar exercise comparing a pre-ban period (April-December, 1976) to a post-ban period (April-December, 1977), showed an average decrease of 22%. The S.D.A. calculations, averaging to about a 21% reduction in influent phosphorus concentration, is the only recent estimate which is supported by hard data. All the remaining estimates examined were either made during an earlier period when the phosphorus content of detergents was much higher than today or they were not supported by data. The 21% figure was therefore used in subsequent cost calculations as the most reliable estimate of the amount of detergent phosphorus concentration in wastewater influent.

E. PROPORTION OF CHEMICAL TREATMENT COSTS ATTRIBUTABLE TO THE PHOSPHORUS CONTENT OF DETERGENTS.

Not many estimates of the proportion of chemical treatment costs attributable to detergents are available. Those who have examined the impact of influent phosphorus concentrations on chemical treatment costs agree that the percentage reduction in the cost of phosphorus removal will be less than the percentage reduction in the phosphorus influent concentration, for the following reasons:

1. The chemicals used to remove phosphorus also react with and remove other wastewater constituents. Thus, a reduction in influent phosphorus concentration does not cause a proportional

reduction in the amount of chemical required to achieve a desired effluent phosphorus concentration.

2. The size of chemical storage tanks are probably not affected by the influent phosphorus concentration, particularly at smaller treatment plants. They are generally designed to store truckload quantities of chemicals.

3. Monitoring costs and certain other operating costs are not affected by influent phosphorus concentrations.

We will now turn to specific estimates. Based on calculations by Mr. Edwin Barth of the E.P.A. Cincinnati Laboratory, it was reported that a one-third reduction in influent phosphorus concentration might reduce chemical and operating costs for phosphorus removal about 20%.*/ This estimate excluded costs associated with sludge handling and disposal. In a subsequent paper by Mr. Barth, it was reported that a 50% reduction in influent phosphorus concentration (10 mg/L reduced to 5 mg/L) would not reduce capital costs associated with chemical treatment, but would reduce operating costs 20-30%.**/ On the basis of the average influent phosphorus concentration reduction observed at Michigan and Minnesota municipal wastewater treatment plants (21%), operating costs for chemical treatment would be expected to

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*/ Detergent Phosphate Ban, Op. Cit., p. 42.

**/ Barth, E. F., and F. M. Middleton, "Trends in Phosphorus Removal Technology for Municipal Wastewater Facilities," presented at a semi-annual meeting of the American Chemical Society, Miami Beach, Florida, September 10-15, 1978, Figure 5.

be reduced 8 to 13% based on the range in Barth's later data.

The I.J.C.'s Great Lakes Research Advisory Board, using a computer simulation model, determined the relative costs for removing phosphorus from wastewater under various scenarios.*/ Making the assumption that there were no controls on detergent phosphorus content and that detergents would contain 12.9% phosphorus, the relative cost figures presented indicated that a detergent phosphate ban could reduce by 25% the capital, operating and maintenance costs for phosphorus removal required to achieve a 1 mg/L effluent phosphorus concentration. Present levels of phosphorus in detergents are less than half of what was used in this study, i.e., 5.5% to 6.0% as opposed to 12.9%. Assuming the relationship is linear, the I.J.C. estimate can be adjusted to reflect the average phosphorus content of detergents sold in non-ban areas of the United States, 5.5% to 6.0%.**/ At the present level of phosphorus in detergents, the percent reduction in capital, operating and maintenance costs for chemical treatment that would be expected to occur in United States' plants as a result of a phosphate detergent ban would be about 11%.

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*/ Annual Report of the Research Advisory Board, July 1977, p. 20.

**/ The assumption of a linear relationship probably results in an estimate somewhat on the high side for the percent reduction in chemical treatment costs. As indicated previously, the relationship between influent phosphorus concentration and chemical treatment costs actually appears to be non-linear, since the reduction in phosphorus concentration would be proportionately greater than the reduction in chemical treatment costs.

F. DETERMINATION OF CHEMICAL TREATMENT COSTS ATTRIBUTABLE TO PHOSPHATE IN DETERGENTS.

Chemical Feed System Costs-Capital

The capital costs for chemical storage and feed equipment assignable to laundry detergent phosphorus removal are small and are in all probability likely to be zero, as stated by Barth.*/ Chemical storage tanks are the largest single item needed, and a minimum-size tank, usually 6,000 gallons, is required to accommodate a 4,000 gallon shipment in a tank truck. For this reason, even small plants will generally use this minimum-size tank regardless of the amount of phosphorus to be treated. For most communities, then, the presence or absence of laundry detergent phosphorus in the influent wastewater will have no effect on the size of the necessary equipment.

However, on the basis of I.J.C. relative cost estimates, as reviewed in the previous section, an 11% reduction in the chemical feed system capital costs could occur with a ban on phosphate detergents. Therefore, a range of capital costs attributable to detergent phosphorus removal at wastewater treatment plants can be estimated on the basis of Barth's and the I.J.C.'s data when they are applied to the average capital cost for chemical treatment equipment reported by

*/ Barth and Middleton, Op. Cit., Figure 5.

the M.D.N.R., updated to June, 1980 (p. 83). The range is as follows:

Chemical Feed System-Capital Cost: $0.00 to $0.12 per capita per year.

Chemical Feed System-Operating and Maintenance Costs

On the basis that (1) the percent reduction in operating and maintenance costs for a chemical treatment plant that would result from a ban on phosphate detergents would range from 8 to 13% (adjusted Barth estimate),*/ and (2) the costs reported for chemical feed system operation and maintenance by the M.D.N.R. (p. 83), the operating and maintenance costs at municipal wastewater treatment facilities that could be attributable to detergent phosphates are:

Chemical Feed System-Operating and Maintenance Cost: $0.17 to $0.28 per capita per year.

Sludge Handling and Disposal-Capital Costs

The percent of capital costs for chemical sludge handling and disposal equipment that would be attributable to detergent phosphate would range between 0% (Barth estimate) and 11% (adjusted I.J.C. estimate). Therefore, based on the M.D.N.R. cost data (p. 83):

*/ The adjusted I.J.C. estimate of 11% falls within this range.

Sludge Handling and Disposal-Capital Cost: $0.00 to $0.15 per capita per year.

Sludge Handling and Disposal-Operating and Maintenance Costs

Using (1) the percent reduction in operating and maintenance costs for a chemical treatment plant resulting from a phosphate detergent ban of from 8 to 13% (Barth estimate),*/ and (2) the M.D.N.R. cost data (p. 83), the operating and maintenance costs for sludge disposal and handling due to phosphate detergents are:

Sludge Handling and Disposal-Operating and Maintenance Cost: $0.12 to $0.20.

Total Cost Reductions

Summing up the various costs presented above, the range for phosphorus removal costs attributable to phosphate detergents is obtained (dollars per capita per year), as of June, 1980:

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*/ Two recent studies of specific plants showed only minor reductions in sludge handling and disposal costs (1% in one study and 4% in the other) after bans were put in place. Dale I. Bates, "Study of Benefits Relative to Phosphorus Removal Costs Resulting from Limitations of Phosphorus in Cleaning and Water Conditioning Agents," June 9, 1978, Western District Office, U.S. E.P.A. (analysis of two Minnesota wastewater treatment plants); Robert Jacke, "Phosphate Ban Lowers Removal Costs," Water and Wastes Engineering, August 1979, pp. 33-35 (analysis of a Michigan wastewater treatment plant).

	Low	High
Chemical Feed System		
Capital	$0.00	$0.12
Operating and Maintenance	0.17	0.28
Sludge Handling and Disposal		
Capital	0.00	0.15
Operating and Maintenance	0.12	0.20
Total Per Capita Cost of Chemical Treatment Attributable to Laundry Detergents	$0.29	$0.75

For the average household of 2.8 persons, therefore, the estimated cost attributable to the removal of phosphorus contributed by phosphate detergents ranges from $0.81 to $2.10.

G. DISCHARGE OF WASTEWATER BY OTHER MEANS.

1. SEPTIC TANK TILE FIELD.

To this point, discussion has centered around the cost of treatment to eliminate phosphorus where the wastewater goes through treatment plants. There are situations where wastewater does not pass through treatment plants *per se*. One is where the wastewater goes into a septic tank tile field system. This system is similar in operation to a primary treatment plant. The major difference between the two is that filtering through the tile field substantially reduces the phosphorus content of any effluent. Efficiently operating septic tank tile field systems seem to eliminate the phosphorus problem so that a ban would be helpful only in case of failure of the systems.*/

It seems clear that the consumers most disadvantaged by a detergent phosphate ban are likely to be the ones who have efficiently operating septic tank tile field systems. This is because they are more likely to depend on ground water supplies which are usually harder than water from other sources and where, as discussed earlier, phosphate detergents tend to be more efficacious. Thus, they receive no direct benefit from phosphate prohibitions, but bear greater direct costs associated with the ban.

2. LAND TREATMENT.

Land treatment is an alternative method of wastewater treatment whereby wastewater which is treated to some degree is discharged directly onto the land surface as the final treatment and disposal step. Vegetation or the ground itself absorbs the constituents from the wastewater. Although clearly the availability of land suitable for this purpose is a constraint on the implementation of this method of treatment, land treatment is used by many municipalities and is in fact the preferred procedure in federally funded wastewater

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*/ Division of Environmental Engineering, Agency for Environmental Conservation, State of Vermont, Report on a Vermont Phosphorus Ban and the Municipal Pollution Control Program, July, 1975, Chapter VI, unpaginated.

management programs.*/ Land treatment often produces independent benefits in terms of reuse of the water and crop production.

This approach involves three major techniques. The first, called slow rate land treatment, applies the wastewater to crops or vegetation. Nutrient removal is effected by the plants and removal of contaminants occurs from seepage through the soil. Wastewater treated in this way has an average phosphorus concentration of less than 0.1 mg/L.**/

The second technique is rapid infiltration land treatment whereby wastewater quickly percolates through highly permeable soils. Especially suitable for harsh climates, this method relies primarily on microorganisms and the soil itself for phosphorus removal. Like the slow rate, the resultant treated water has about 0.1 mg/L phosphorus.***/

The last method, overland flow land treatment, involves passing the wastewater over the land surface to collection ditches. Because this procedure is employed where the

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*/ U.S. E.P.A., U.S. Army Corps of Engineers and U.S. Dept. of Agriculture, Process Design Manual for Land Treatment of Municipal Wastewater, E.P.A. 625-77-008, October, 1977, p. 1-3. Municipalities requesting federal funds for wastewater treatment are now "required to provide complete justification for rejection of land treatment." U.S. E.P.A. memorandum from Douglas M. Costle dated October 3, 1977.

**/ Ibid. (first citation), p. 2-4.

***/ Ibid., pp. 2-4 and 2-11.

ground is relatively impermeable, overland flow has more limited phosphorus removal capability, usually on the order of 30% to 60%.*/ However, overland flow is not a widely-used land treatment method.

Phosphorus removal by any of these three techniques of land treatment does not require special equipment or processes designed specifically for phosphorus control. Households linked with municipal wastewater treatment systems using the predominant land treatment methods (slow rate and rapid infiltration) thus derive no real benefit from a ban, but still must absorb the costs.

3. "LUXURY" UPTAKE.

New biological processes, called "luxury" uptake, have been developed which utilize certain microorganisms in the wastewater treatment system to remove phosphorus and other nutrients. These microorganisms, which concentrate high levels of phosphorus within their own cells, are then removed with the sludge. Depending upon which technique is used, this can be accomplished either by normal sludge removal or by chemical treatment.

Because this method is an emerging field of wastewater treatment technology, only a few treatment plants are presently equipped to remove phosphorus by biological means. As one author pointed out:

*/ Ibid., p. 2-14; M. R. Overcash, "Implications of Overland Flow for Municipal Wastewater Management," Journal, Water Pollution Control Federation, October 1978, pp. 2337-2347.

> While many conventional treatment plants remove nutrients under some conditions with a surprising degree of efficiency, attempts to quantify the processes involved, so that they can be applied elsewhere, have produced limited success. */

Due to the newness of this area, there are insufficient data available to determine the costs associated with detergent phosphate removal at such facilities. The operating costs of phosphorus removal would appear to be lower than conventional chemical treatment because the use of chemical coagulants can be reduced or eliminated. The economic feasibility of the possible implementation of these systems would depend on a number of factors, such as the ease of installation at existing facilities and their ability to reduce or eliminate chemical use and to produce sludges with high fertilizer value.

H. FEASIBILITY OF CHEMICAL TREATMENT.

A final issue is whether it is feasible to install chemical treatment at the various wastewater treatment facilities. The E.P.A., Region V, concluded that one of the reasons supporting a phosphate ban was that, in some cases, "... phosphorus removal equipment cannot be installed where it is needed

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*/ David W. Bouck, "Nutrient Removal in Three-Stage Processing," M. P. Wanielista and W. W. Eckenfelder, Jr. (eds.), Advances in Water and Wastewater Treatment Biological Nutrient Removal (Ann Arbor Science, 1978), p. 67.

because of lack of funds ..." */ The statement appears to be that one can impose indirect costs on consumers where it would not be possible to increase taxes, or to raise water rates, to cover treatment costs. Efficient resource allocation requires of government (as it does of the private sector) that the cheapest alternative be used from a cost-benefit standpoint.

It requires time to install chemical treatment. Chemical storage tanks and feed equipment must be installed and provisions must sometimes be made for handling the additional sludge. It is generally conceded, however, that the process can be installed in a relatively short period of time. Occasionally it is argued that a ban should be put in place temporarily until chemical treatment can be made operational. The "time lag" could be an argument for a ban if it could be demonstrated that the amount of phosphorus removed during the temporary period would have such a material effect on retarding eutrophication that it would justify the consumer costs imposed. **/ Previously cited material suggests that the marginal elimination of phosphorus from water bodies may have little, if any, effect (see pages 14-17 of this paper). If

*/ Detergent Phosphate Ban, Op. Cit., p. 4.

**/ The costs to consumers and sellers may be somewhat greater in a temporary removal of phosphate detergents due to the uncertainty created and the greater initial adjustment, and then readjustment, costs.

the benefits were great, a better alternative may be to make greater expenditures to obtain more expeditious installation of chemical treatment capability since this approach has been shown to deal with phosphorus removal more effectively.

VI. COMPARISON OF CHEMICAL TREATMENT COSTS TO PHOSPHATE BANS.

In general, our estimate is that a ban would generate about $11.10 per year per household (as of June, 1980) in added consumer costs to an average household, without considering (1) the wear-out of washable fabrics, (2) deleterious consequences on the serviceable life and performance of washing machines, (3) increased installation of mechanical water softeners, (4) consumer welfare losses due to homemakers having to accept a lower level of satisfaction with their washing results, despite making the available adjustments, and (5) greater producers' costs, which can be expected to be passed along to consumers to a significant degree. This can be compared to an average annual cost (as of June, 1980, also) of $0.81 to $2.10 per household for the chemical treatment necessary to remove detergent phosphorus at wastewater treatment plants.

Because we are talking about recurring costs, year after year into the foreseeable future, it is appropriate to compare the present value of these streams of expenditures. Since a dollar to be paid next year is not worth a dollar paid this year, this future expenditure stream must be discounted to the present day by a "discount rate,"*/ for which we have used 10%.**/ This then implies a present discounted value of $94.51 per household for the consumer costs of a ban compared to a present discounted value of $6.90 to $17.88 per household today for chemical wastewater treatment.

In light of these estimates and the material we have reviewed, several observations can now be made. First, if the choice confronting regulatory authorities were thought to be between bans and chemical treatment, bans could not be selected as the appropriate policy instrument on the basis of objective cost criteria. Bans would cost from five to thirteen times as much as chemical treatment to remove detergent

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*/ A way to understand this concept is to imagine that a dollar a year must be paid for a number of years. A dollar paid in each future year is not worth a dollar today. The dollar to be paid next year can be invested now and be earning interest or dividends before it has to be paid. At a 10% rate of interest, that dollar paid next year is worth only $0.909 today. A dollar paid in two years is worth only $0.826 now. And so on. The present value, then, is the sum of these year-after-year expenditures in the future.

**/ The 10% discount rate has been used in a number of other cost-benefit studies because it "roughly corresponds to the long-run average rate of return on equities." Sam Peltzman, "An Evaluation of Consumer Protection Legislation: The 1962 Drug Amendments," Journal of Political Economy, Vol. 81, No. 5 (September/October 1973), p. 1075. We have used twenty years as the appropriate time frame for which to measure these recurring expenditures because the M.D.N.R. capital cost figures, used in our estimate, were spread over a twenty year period.

phosphorus and they would still not remove sufficient detergent phosphorus to attain the societally acceptable effluent standard of 1 mg/L. This latter point has been recognized by the I.J.C. and E.P.A. and is supported by various studies cited earlier (see pages 14-17 of this paper).

Second, it is also clear that bans do not result in a sufficient savings in chemical treatment costs, including capital, operating and maintenance of chemical feed systems and sludge handling, to justify the other costs that they impose. In terms of present discounted value, how can it be cost-effective to incur more than $94.51 per household in costs due to a phosphate ban to save some portion of a cost ranging from $6.90 to $17.88 per household for chemical treatment during the same period?

VII. CONCLUSION.

We have undertaken a review of the relevant literature and we have examined the studies which have been performed on the issue of phosphate bans and chemical treatment. Our appraisal is that, while each study has limitations and can be subject to criticism, overall they demonstrate that bans generate quite significant consumer and producer costs. Compared to the major alternative, chemical treatment, bans are not a cost-effective way to deal with the perceived problem, either in terms of reducing phosphorus effluent levels or in terms of saving treatment costs.

It is evident that there is considerable reluctance by the regulatory authorities to fully appreciate the costs to consumers in evaluating phosphate bans and a tendency to treat them as having lesser importance than the direct governmental expenditures involved in funding chemical treatment capability. The consumer costs are diffuse and hard to recognize even by homemakers themselves, as being attributable to the absence of phosphate detergents whereas the costs of chemical treatment are clear and conspicuous. Further, bans may appear more politically acceptable because they are seemingly easy to impose and enforce*/ and may be a quick and popular response to "dealing with the problem." However, as a recent government

*/ Enforcement may seem simple at first glance - just pass a law prohibiting the retail sale or consumption of the product and there will be compliance. However, "bootlegging" of phosphate detergent from outside a ban area by consumers can continue as a significant enforcement problem, as can the monitoring of compliance by hundreds, if not thousands, of retail outlets in a larger ban area. Small municipalities with limited resources may have difficulty compelling adherence to such an edict. Presumably, however, there will be some policing in most ban areas and those enforcement costs are attributable to the bans. Consumer cost estimates should also be reduced accordingly to account for non-compliance.

study pointed out:*/

> In addition, we find that all too often basic regulatory decisions are based on insufficient analysis and consideration of alternatives. Government intervention should not occur merely because there appears to be a problem in need of a remedy. Instead, government controls should be imposed only where there is a clearly defined problem, and where the projected accomplishments are both significant and not rendered detrimental by serious adverse consequence which result from that action.

Whether phosphate bans are really "popular" is, we suppose, subject to debate, particularly in light of some of the surveys showing a substantial amount of dissatisfaction with non-phosphate detergents and the significant consumer adjustments in post-ban periods. The E.P.A., Region V, report, however, perceived not only a "very low level of consumer dissatisfaction" with bans, but also "rising consumer acceptance" and "general public support for a phosphate ban."**/ The bases for these statements are not well-detailed, but include such reasons as that bans remain in effect "despite determined detergent industry opposition," conversations by the Region V staff with Midwest consumers in ban areas and with non-phosphate detergent manufacturers, growth of liquid detergents, and the personal laundering experiences in Chicago (a ban area) of the six or seven authors of the report. None of these reasons

*/ Study on Federal Regulation, Committee on Governmental Affairs, U.S. Senate, 95th Congress, 2d Session, Framework for Regulation, Vol. IV, December, 1978, p. 3.

**/ Detergent Phosphate Ban, Op. Cit., p. 59.

seems especially probative. Suffice it to say that if a consumer product is outlawed, people will adapt, consciously or unconsciously, and learn to live with it. The consumer cost section illustrates, we think, that these adjustments cost money. Whether bans are "accepted" or not is irrelevant. The issue is whether that is the most cost-effective way for governmental authorities to achieve their objectives -- a reduction in phosphorus levels.

The easy solution or political expediency is not sound governmental policy, which demands a careful assessment of all of the relevant costs and benefits of regulatory action generally and a considered appraisal of the cost-effectiveness of alternative methods of implementing a program. The consumer (and producer) costs of a ban exist, they are significant and they are as real as direct expenditures by government. Ignoring these costs is tantamount to the imposition of a hidden tax on consumers, a tax which seems to be a several-fold higher than any levy necessary to support chemical treatment.

The data amply support a conclusion that, in view of the more cost-effective alternatives, a phosphate ban is not an economically efficient course of action. This is reinforced by the fact that it is generally thought that chemical treatment is necessary <u>whether or not</u> a phosphate ban on laundry detergent is imposed in order to accomplish even the current objectives at wastewater treatment plants.*/

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*/ That is, the 1 mg/L phosphorus level in sewage effluent. The I.J.C. has considered whether the effluent limit should be lowered to a tenth of that, i.e., 0.1 mg/L, in the Great Lakes basin. Detergent Phosphate Ban, Op. Cit., p. 3. In view of the significant loadings of phosphorus from other sources than sewage (e.g., atmospheric transference and run-off of agricultural fertilizers) and the apparent need to reduce loadings materially to have an effect in the most eutrophic lakes (see pp. 14-17 of this paper), we hope that all these costs -- both of bans and chemical treatment -- will have a significant impact in retarding accelerated eutrophication. We leave that issue for others, more qualified than we are in this regard, to judge.

APPENDIX

POPULATION OF STATES, COUNTIES AND MUNICIPALITIES WHICH HAVE ENACTED A TOTAL BAN OR LIMITATION ON PHOSPHATES IN LAUNDRY DETERGENTS AS OF JULY, 1979

(Population as of July 1, 1976)

Area	Population
I. Total Phosphate Ban in Effect	
States 1/	
Indiana	5,313,034
New York	18,073,232
Minnesota 2/	3,970,576
Michigan	9,142,782
Vermont	480,509
Wisconsin 3/	4,610,871
Counties	
Dade County, Florida	1,439,410
Lake County, Illinois 4/	406,202
Municipalities	
Aurora, Illinois	78,414
Chicago, Illinois	3,074,084
Crystal Lake, Illinois	18,068
Elgin, Illinois	60,718
Elmwood Park, Illinois	25,460
Harwood Heights, Illinois	9,065
Northlake, Illinois	12,764
Park Forest, Illinois	32,881
Kankakee, Illinois	27,429
Bridgton, Maine	3,192
Naples, Maine	1,414
Alton, New Hampshire	2,011
Center Harbor, New Hampshire	645
Meredith, New Hampshire	3,520
Moultonboro, New Hampshire	1,737
Akron, Ohio	249,815
Cuyahoga Falls, Ohio	46,448
Fairlawn, Ohio	6,784
Independence, Ohio	6,562
Monroe Falls, Ohio	4,237
Stow, Ohio	24,809
Tallmadge, Ohio	15,999
North Olmstead, Ohio	38,028
Subtotal for total phosphate ban	47,180,700

II. 8.7% Phosphorus Limitation

States	Population
Connecticut	3,102,293
Florida 5/	8,359,048
Maine 6/	1,072,588
Counties	
Prince George's County, Maryland 7/	674,139
Municipalities	
Franklin Park, Illinois	18,655
Highland Park, Illinois	31,412
Hillside, Illinois	8,561
Lombard, Illinois	36,904
Morton Grove, Illinois	26,280
Guilford, New Hampshire 8/	4,504
Euclid, Ohio	62,692
Painesville, Ohio	15,980
Willowick, Ohio	19,390
Milwaukee, Wisconsin 7/	661,082
Subtotal for 8.7% phosphorus limitation:	14,093,528
Total population covered by phosphate ban or limitation: 9/	59,137,718
Total U.S. population	214,669,000
Percent of U.S. population covered by ban or limitation	27.5 %
Percent of U.S. population covered by ban (from Section I)	22.0 %

1/ Iowa is not shown, but legislation has been passed which enables a phosphate ban or limitation to be implemented.

2/ Minnesota enacted a total ban on phosphates in 1976, but enforcement was enjoined from January, 1977 to 1979 pending the outcome of a suit filed.

3/ Madison, Wisconsin, has separately enacted a ban which applies only to city purchases.

4/ Lake Zurich, Illinois, in Lake County, also has a total phosphate ban.

5/ An 8.7% phosphorus limitation has also been enacted in Florida by Lake County, Pineallas County, Orange County, and the municipalities of Cocoa Beach and Kissimmee.

6/ Kennebunkport, Maine, limits phosphorus content to a maximum of 14%.

7/ Prince George's County permits an option of 8.7% phosphorus limitation or 7 grams phosphorus per recommended use level. Milwaukee's limitation is 7 grams phosphorus per recommended use.

8/ Guilford, New Hampshire limits phosphorus in substantial quantity, but no actual level is specified.

9/ Double counting has been eliminated for (1) Dade County, Florida, and Bridgton and Naples, Maine which have bans in place, but are also covered by a state-wide limitation; (2) Milwaukee, Wisconsin, which, although under a state-wide ban, also has enacted a limitation of 7 grams phosphorus per recommended use; and (3) Highland Park, Illinois, which has an 8.7% phosphorus limitation, but is located in Lake County, Illinois, which has a ban.

Sources: Areas with a total ban in effect were provided by the Soap and Detergent Association; Population Data is from Population Estimates and Projections, Series P-25, Current Population Reports, Bureau of the Census, U.S. Department of Commerce.