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Potomac River Basin
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POINT AND NONPOINT POLLUTION SOURCES

TIME FOR A REEVALUATION

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During the past twenty years there have been two trends in the management of water quality that are presently having a profound effect on our concept of wastewater treatment in the Potomac River basin and throughout the nation.

First, there has been a shift in concern from organic to inorganic substances in surface waters. Biochemical oxygen demand (BOD), attributable to organic wastes in domestic sewage and industrial wastewater, has been supplanted by inorganic chemicals which accelerate "eutrophication," the premature aging of lakes and estuaries. These inorganic compounds include various forms of nitrogen and phosphorus, ubiquitous nutrients in nature.

Second, the reduction in gross pollution from industrial and domestic wastes has transferred attention from substances in "point" source discharges to those originating from "nonpoint" sources. A point source is usually associated with the discharge from a pipe, but may be from a mine-mouth or other clearly identifiable outfall. All other sources, such as farm land and urban drainage ways, are referred to as nonpoint. Federal and state pollution control programs, directed during the past two decades toward control of such point sources as municipal and industrial wastewater treatment facilities, have begun to show progress in reducing the major sources of oxygen-demanding wastes. However, water quality monitoring designed to measure this progress reveals that control of point sources may not be sufficient to achieve future water quality goals.

THE POINT ISSUE

Water pollution control in the Potomac River basin, particularly in the Washington Metropolitan Area, is an excellent example of these trends. Under drought conditions experienced during 1969 and 1970, when the flow of the Potomac River into the tidal estuary at Washington had dropped to 1,200 cfs (cubic feet per second), the percentage of pollutants contributed from local wastewater treatment facilities was very high.[1] Point sources contributed 87 percent of the BOD, 96 percent of the total phosphorus, and 90 percent of the total nitrogen (Table 1). Under median flow conditions of approximately 6,470 cfs, the respective percentages of pollutants contributed from point sources in the metropolitan area dropped significantly, reflecting the pollutants contributed from point and nonpoint sources upstream of Washington.

Progress on the Potomac Estuary--For the past forty years the major point source of treated wastewater entering the Potomac at Washington (or anywhere else in the river basin) has been the Blue Plains Wastewater Treatment Plant. In 1970, the total BOD loading to the Potomac estuary from wastewater treatment plants was 141,000 pounds per day, of which 104,000 pounds was attributed to Blue Plains. The ratios for nitrogen and phosphorus were similar (Table 2). The Blue Plains plant was by far the largest discharger by volume, with an average of 251.7 mgd (millions gallons per day), compared to 23.3 mgd by the Alexandria plant, and 19.4 mgd by the Arlington plant.

Even though the wastewater flow at Blue Plains has continued to increase steadily, reaching the designed average capacity of 309 mgd in 1978, multimillion-dollar capital improvements at the facility have steadily reduced its discharged pollutant loadings. By 1974 the loadings to the estuary had been reduced to 100,000 pounds per day of BOD and 10,000 pounds per day of phosphorus. Reports for August 1978 show that the total loading for BOD has been reduced to 70,000 pounds per day and for phosphorus to 4,500 pounds per day.[2] Although discharge permit conditions are still occasionally violated, these improvements in treatment capability at the Blue Plains plant and at other large treatment plants in the Washington area appear to have

Table 1.--Relative Biochemical oxygen demand, nitrogen, and phosphorus contributed to the Potomac estuary from Washington Metropolitan Area point sources under selected Potomac River flow conditions at Washington, D.C., 1969-70

Pollutant	Relative contribution from point sources	
	1200 cfs	6400 cfs
BOD	87%	62%
Phosphorus	96%	82%
Nitrogen	90%	60%

Table 2.--Biochemical oxygen demand, nitrogen, and phosphorus loadings to the Potomac estuary from the Blue Plains Wastewater Treatment Plant compared to all point sources in the Washington Metropolitan Area, 1970

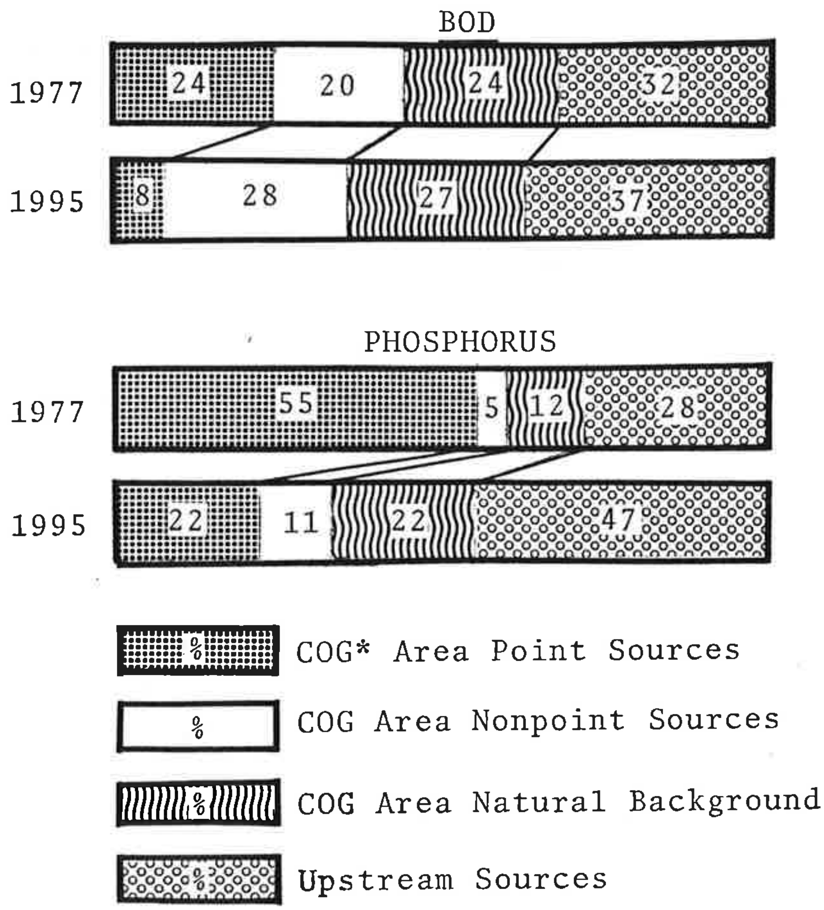
Pollutant	Blue Plains	All point sources
	Load, lbs/day	
BOD	103,800	141,000
Phosphorus	48,200	59,500
Nitrogen	14,300	24,000

caused a major change in the relative contributions from point and nonpoint sources of pollutants that enter the estuary at Washington.

A wastewater management plan developed by the Metropolitan Washington Council of Governments (COG) under Section 208 of the Federal Water Pollution Control Act (P.L. 92-500) has shown that, as the effectiveness of point source control progresses, the percentage of annual BOD loading from point sources to the estuary is projected to drop from 24 percent in 1977 to 8 percent in 1995.[3] Phosphorus is projected to follow the same trend, dropping from 55 percent to 22 percent for point sources in the Washington area (Figure 1). These calculations were based on the average daily loads flowing into the estuary from the Blue Plains, Piscataway, Arlington, Alexandria, and lower Potomac treatment plants.

Efforts to Reduce Nutrients and BOD--Why has there been such an intense effort in the Washington area to reduce BOD, phosphorus, and nitrogen loadings to the Potomac estuary? To find the answer, we must begin in the late 1950's, when population growth was overwhelming the improvements in wastewater treatment facilities. In 1957, the Public Health Service held the first Potomac Enforcement Conference, an interstate meeting on pollution in the Potomac. Concern was expressed then for the organic loading discharged to the

Table 3.-- Estimated Annual Relative Biochemical Oxygen Demand and Phosphorus Loadings To The Potomac Estuary, 1977 and 1995



* Council of Governments of the Washington Metropolitan Area

Potomac--equivalent to the raw wastes of 1,143,000 people. Recommendations were made that included taking action to remove 80 percent of the inflowing BOD. These recommendations were not implemented, and during the 1960's the situation worsened. Nuisance aquatic plants completely covered portions of the estuary and clogged tributary systems. The Conference was reconvened in 1969, and as a result of observing the Potomac and of research on excess nutrients, the center of attention became the need to remove phosphorus from wastewater processed by municipal wastewater treatment plants.[4] This conference recommended efforts be undertaken to achieve 96 percent removal of BOD and phosphorus at point sources, and a preliminary goal to reduce ammonia nitrogen to zero, including 85 percent total nitrogen removal.

Further research and support for nutrient control in the estuary was presented in a 1971 report by the EPA's Chesapeake Technical Support Laboratory. This report, known as Technical Report 35, documented the occurrence from June through October of 1969 of large populations of blue-green algae, forming thick mats in the Potomac estuary from the Potomac River Bridge, which carries U.S. Route 301 between Maryland and Virginia, to the Woodrow Wilson Bridge, which carries I-495 across the river south of Washington. The report also noted that, after a period of low flow and high temperatures that occurred in September of 1970, the algal mats extended further upstream to near the 14th Street Bridge and included the first nuisance growth within the Tidal Basin.[1] The investigators determined that to control future outbreaks of blue-green algae in the estuary, ambient nitrogen and phosphorus concentrations in the upper estuary would have to be limited to 0.3 mg/l and 0.1 mg/l (milligrams per liter), respectively.

The EPA (Environmental Protection Agency) based its effluent standards on these recommendations of the Potomac Enforcement Conference and Technical Report 35, and applied them to Blue Plains and other plants in the Washington Metroplitan Area. The decision to require 85 percent removal of nitrogen was made without either a quantitative estimate of the benefits to be gained from removing nitrogen in addition to phosphorus or an accurate estimate of the costs involved. As a result, the EPA acted in 1975 to postpone the requirement for denitrification at the Blue Plains plant.

THE NONPOINT ISSUE

While progress was being made in reducing pollutants from sewage treatment plants or "point" sources, research conducted on stormwater runoff was suggesting that pollutants from nonpoint sources were as serious as those from point sources, if not more so. This issue has had much attention over the last few years, with the result that federal legislation now requires the states and others to develop water quality management plans to deal with runoff from rural, suburban, and urban lands. Although there have been occasional discussions on treating urban stormwater runoff to remove these pollutants, most regulatory agencies have undertaken the development of Best Management Practices (BMPs) which, when applied to various land uses, may achieve the desired effect of reducing pollutant loadings to the river and estuary.

Programs for developing BMPs have been approached cautiously in the Potomac River basin because of their potential impact on landowners and those who make their living from the land. Such issues as who will finance, maintain, and measure the success of these practices have not been resolved, nor are they likely to be in the near future. Use of the word "regulate" has been avoided, and most programs stress the voluntary nature of their management.

On the other hand, there have been a number of studies that have implied water quality goals cannot be met without strict control of nonpoint sources.[5] The conflict of these implications with landowner's rights and the rising costs of pollution control have created a situation that needs much more supporting data and information before it will be resolved.

Problems in Evaluating Nonpoint Sources--Determining the source and impact of nonpoint pollution has been an imprecise affair. Most efforts have shown how much nonpoint pollution was present, not where the pollution came from, whether it was the result of man's activities or natural processes, or, more importantly, what its impact on water quality was. In some cases, estimates of the overall extent of nonpoint pollution have been extrapolated from existing data relating to point sources. Officials of one state agency in the Potomac River basin reported that they determined the nonpoint pollution loading on a few stream segments by substracting the pollution load attributable to point sources from the total pollution load in the stream. These and other more complex problems in evaluating the presence and sources of nonpoint sources, specifically phosphorus, exemplify the difficulty of making the process more accurate.

First, during high-flow periods the concentration of phosphorus in streams is influenced by point source phosphorus which may have been stored in the stream bed during low-flow periods. Next, there is the additional complication of the phosphorus from nonpoint sources being transported to the stream by overland flow. Also, phosphorus reacts very strongly with the soil. Therefore, eroded soil material transported by overland flow of water is likely to carry a significant amount of phosphorus into the receiving waterways. Estimating this phosphorus loss requires an estimate of the phosphorus content of soil particles, and the very small particles are the most erodible. Such particles have a higher relative reactivity with phosphorus and, hence, compared to the soil as a whole, are proportionately richer in phosphorus. Consequently, during high-runoff periods the concentration of phosphorus associated with particulate material in suspension may be very high compared with that which is in solution.

Another matter that complicates an understanding of phosphorus is its definition. This element is found in a great number of chemical and physical combinations, and many measurements based on available analytical methods have no biological meaning, per se. There are important differences between the forms of phosphorus in point sources and nonpoint sources, and there are also important differences between the phosphorus in free flowing streams and that found in lakes, estuaries, and other quiescent bodies of water. These differences determine the effect of phosphorus upon aquatic life. But, aquatic scientists have no general agreement on which forms of phosphorus are "biologically available," a problem that has received remarkably little discussion in the scientific literature.

BIOLOGICALLY AVAILABLE PHOSPHORUS

Researchers at Cornell University coined the term "biologically available phosphorus" (BAP) to identify that fraction of phosphorus that is available to aquatic life. Based on an analysis performed in the Fall Creek watershed in New York, they reported that the biologically available fraction of phosphorus is probably less that 25 percent of the total phosphorus in the stream for an average year.[6] This conclusion has had a tremendous effect on the choice of techniques and programs for phosphorus management because a high proportion of the BAP occurs in wastewater. Consequently, these researchers determined that the reduction of BAP that is achieved through tertiary treatment of municipal sewage is much more effective than that which could be achieved through reducing soil erosion.

The Fall Creek study examined both the effects of phosphorus on algal productivity and ways by which levels of phosphorus could be reduced in surface waters. The analysts estimated that, following the ban on phosphates in laundry detergents, the effective methods of controlling inputs of the BAP to lakes, in ascending order of estimated costs, would be

--by tertiary treatment of domestic sewage,

--by the control of barnyard runoff,

--by changing from row crops to non-row crops, and

--by control of land runoff by altering manure handling practices.

The relative magnitude of these costs as determined in the Cornell studies is presented in Table 3.

Of the various agricultural sources of phosphorus, apparently one of the easiest and least expensive to control is barnyard runoff. However, an argument is that, because of the nature of these wastes, the removal of phosphorus from animal wastes by some treatment process is not economical, and even impractical, given current methods of animal production. Since animal production facilities are usually in the vicinity of grassland, cropland, or brushland, disposal on these areas appears to be the obvious strategy.

FUNDING FOR AN UNDEFINED PROBLEM

For some time, methods for managing nutrient flows on land have included timing the application of fertilizers and manures, controlling the amount applied, and utilizing recommended cropping and soil conservation practices.

Table 3.--Estimated costs of reducing phosphorus inputs from Fall Creek into Cayuga Lake, New York, 1975

Method	Phosphorus reduction Cost per pound
Tertiary treatment of domestic sewage	$26
Control of barnyard runoff	$66 to 331
Reduce corn acreage and shift to non-row crops	$897
Avoidance of manure spreading in winter*	$1,263 to 2,274

*The cost of deferring manure spreading will be offset by undetermined benefits when the manure is utilized in the spring.

However, priorities must be established to assure that the practices and management techniques selected will most benefit water quality in a given area.

Several new efforts and programs will have a significant future effect on agricultural and other rural sources of nonpoint pollution. Some amendments to the Clean Water Act of 1977 apply to Section 208 of P.L. 92-500. These provide for the local soil conservation districts to enter into contracts with owners and operators having control of rural land for the purpose of incorporating BMPs to control nonpoint sources of pollution.[7] The improvement of water quality in critical areas is the goal of this program, and the level of funding authorized in the Act for fiscal Year 1979 totaled $200 million, with an additional $400 million authorized for fiscal year 1980. However, Congress appropriated no funds under this authorization for FY 1979. This proposed funding is in addition to those funds which are routinely authorized for such programs as the Agricultural Conservation Program and regular soil conservation district operations. Although the full level of funding has not yet been provided, the amendments indicate the level of concern and interest being directed to this relatively undefined problem.

THE OCCOQUAN STORY

The need for adequate information prior to implementing land-use controls and BMPs to control nonpoint pollution cannot be overemphasized. Lack of such information has led to a controversy about the Occoquan watershed, a 570-square-mile area in Northern Virginia, tributary to the Potomac near Washington. The Occoquan Reservoir is situated in the lower portion of the watershed and provides a water supply for approximately 650,000 Virginians. Over the years the reservoir has experienced progressively worsening nuisance aquatic plant growths that require extensive use of copper sulfate for control. Early reports by the Occoquan Watershed Monitroing Laboratory (OWML), which routinely measures water quality conditions in the reservoir and its tributaries, tentativley identified stormwater runoff as the culprit to be blamed for eutrophication of reservoir waters.[8] This finding left many wondering whether it had been wise to invest millions of dollars in a new, highly sophisticated advanced wastewater treatment plant designed to remove what appeared to be a relatively small percentage of the total pollutant load to the reservoir.

Drought conditions in 1977 allowed the OWML to assess better the impact of treated sewage discharges on reservoir water quality in the absence of any runoff-generated nonpoint pollution. As a result, the OWML reversed its previous interpretation and concluded that water quality behavior in the reservoir was totally dominated by the phosphorus discharged from the then existing sewage treatment plants, which were to be replaced in the summer of 1978 by a new advanced wastewater treatment plant. The most significant matter associated with this reversal of opinion is that OWML pointed out several areas where there was a lack of information necessary to determine the impact of nonpoint sources. Specifically, there is little knowledge of how much of the total nonpoint source load is retained in the reservoir, the form of phosphorus contained in the load, or the relative availability of this phosphorus for algal growth.[9]

Even though the need for additional information has been recognized in the Occoquan, the data presently available are much more extensive than that in the remainder of the Potomac River basin, and quite likely more than has been collected in many other areas of the nation. For the most part, the data colllected have not been those necessary to make an accurate assessment of what the impact of nonpoint sources may be in specific instances. Even so, programs are being developed to control nonpoint pollution on a very broad base, utilizing far less data for decision-making than that available in the Occoquan. To develop an adequate nonpoint pollution control program, more and better data are needed on specific sources of nonpoint pollution and their impact on water quality. Furthermore, data must be developed to show what water quality improvements are to be derived from various control techniques.

IMPROVEMENTS "POINT" THE WAY

On a much larger scale, significant improvements in the water quality of the Potomac estuary at Washington have been noted during the last few years.[10] The 1977 drought which had such a devastating effect on the Occoquan was also experienced in the Potomac, and, although the river flow did not quite reach the record low flows of 1969 and 1970, the situation was right for a reoccurrence of the nuisance algal mats that were such a problem in those years. Was it merely coincidental that at a time when significant progress was being made in reducing the point source loadings of BOD and phosphorus from the Blue Plains treatment plant and others, that the nuisance algal blooms did not return? An explanation is not readily available. But, clearly there is still a lot to learn about the behavior of water quality in the estuary and its tributaries. Meanwhile, removing phosphorus from point sources would appear prudent, through a ban on phosphate detergents or removal at treatment plants, even before a land-based management program that may have relatively little impact on nutrient enrichment is attempted.

References

1. Jaworksi, Norbert A., et al. 1971. A Water Resource Water Supply Study of the Potomac Estuary. Technical Report 35. Chesapeake Technical Support Laboratory, EPA.

2. Jones, Edward. 1978. Department of Environmental Services, Washington, D.C., personal communication.

3. Metropolitan Washington Water Resources Planning Board. 1978. Draft Metropolitan Washington Water Quality Management Plan. Metropolitan Washington Council of Governments, Washington, D.C.

4. Palmer, Richard N. 1975. "Nitrogen Removal: Misunderstood in 1969, Uncertain Now." Potomac Basin Reporter. ICPRB, Bethesda, Maryland. February.

5. U.S. General Accounting Office. 1978. National Water Quality Goals Cannot Be Attained Without More Attention to Pollution From Diffused or "Nonpoint" Sources. CED-78-6.

6. Porter, Keith S. 1975. Nitrogen and Phosphorus-Food Production, Waste and the Environment. New York State College of Agriculture and Life Sciences, Cornell University, Ithaca, New York.

7. Water Pollution Control Federation. undated. The Clean Water Act-Showing Changes Made by the 1977 Amendments. Washington, D.C.

8. Randall, Clifford W., Thomas J. Grizzard and Robert C. Hoehn. 1978. Effect of Upstream Control on a Water Supply Reservoir. Journal of the Water Pollution Control Federation. December. pp. 2687-2702.

9. Randall, Clifford W. and Thomas J. Grizzard. 1978. Sources of Misunderstandings Concerning the Pollution Problems of the Occoquan Reservoir. Occoquan Watershed Monitoring Laboratory, Manassas, Virginia.

10. Clark, Leo J. and Stephen E. Roesch. 1978. Assessment of 1977 Water Quality Conditions in the Upper Potomac Estuary. EPA 903/9-78-008.