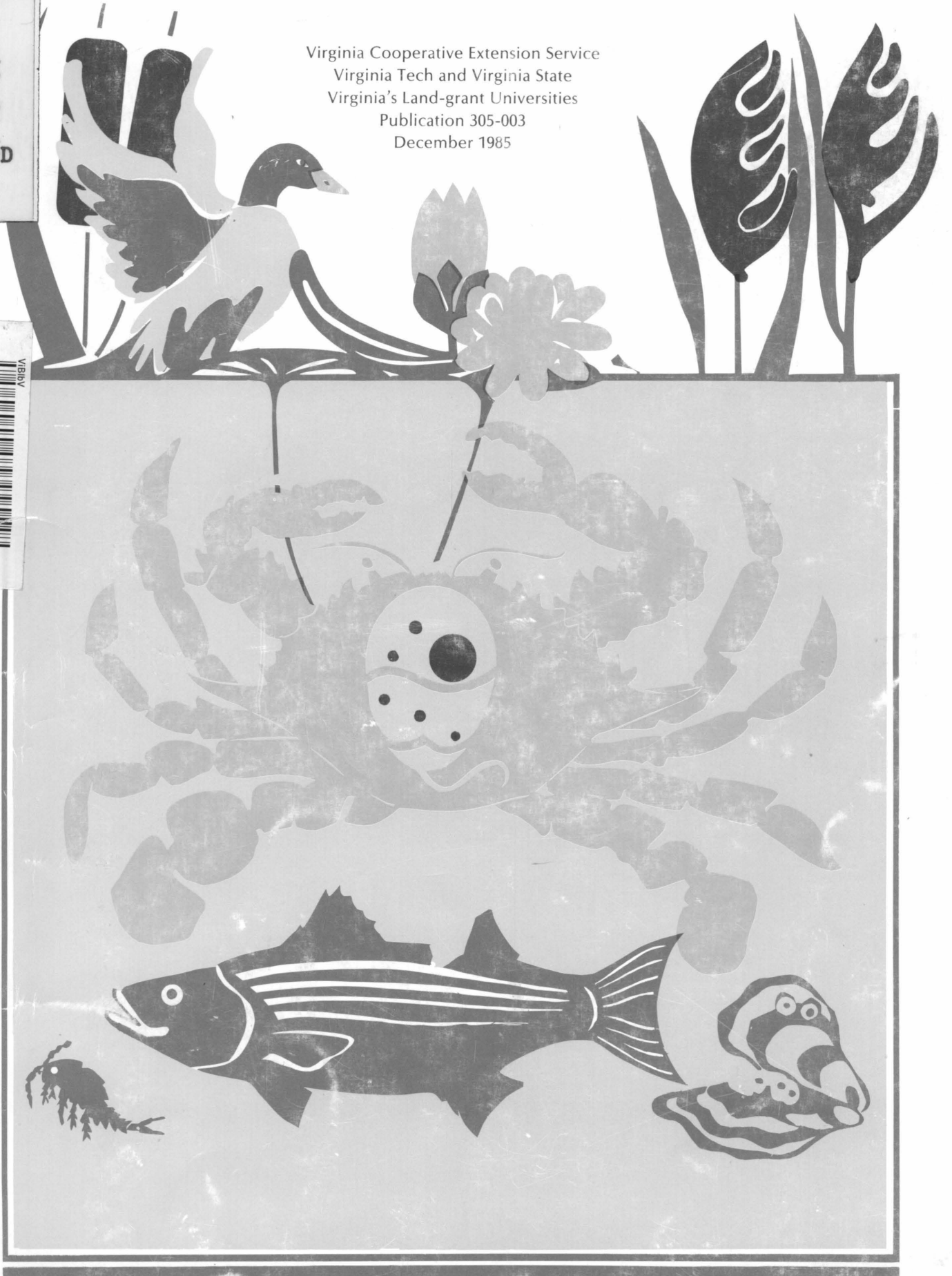


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## Land Use and the Chesapeake Bay

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## ABSTRACT

The inflow of land-based pollutants has decreased productivity of the Chesapeake Bay. Better land-use management practices can improve the service-providing capacity of the bay. Specific approaches to management of pollutant sources are discussed. Solutions to some institutional, ethical, and legislative issues are presented for action on both the individual and collective level in a series of 15 papers.

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Proceedings of a Conference  
on  
LAND USE AND THE CHESAPEAKE BAY

Charles W. Coale  
J. Paxton Marshall  
Waldon R. Kerns

Editors

Virginia Cooperative Extension Service  
of  
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U.S. Soil Conservation Service  
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CONTENTS

Page

Preface ..... v

Sources and Impacts of Nutrients in the Chesapeake Bay ..... 1  
Gail B. Mackiernan

Management of Agricultural Drainage Water to Minimize  
Nutrient Inputs to Estuaries and Bays..... 21 ✓  
J. W. Gilliam and R. W. Skaggs

Crop Fertilization That Will Reduce Pollution of Surface  
Waters ..... 31 ✓  
George W. Hawkins

The Role of Fertilizer and Agri-Chemical Best Management Prac-  
tices (BMPs) in Reducing Bay Pollution: Herbicides..... 37 ✓  
D. Raymond Forney and Chester L. Foy

Managing Fertilizer and Agri-Chemical Use Within the Bay  
Watershed: Fungicides, Nematicides, and Insecticides ..... 45 ✓  
Patrick M. Phipps

Virginia Agricultural and Urban Best Management Practices  
Programs..... 51 ✓  
C. Scott Crafton

o Legislation: What Is? What Ought To Be? The Role of State  
Law in Improving Land-Use Management Within the  
Virginia Portion of the Chesapeake Bay Watershed ..... 59  
William E. Cox

Land Application as An Alternative for Treatment  
of Municipal Wastewater ..... 73  
Donald J. Epp

Selected Industrial/Commercial Development in the  
Hampton Roads Area ..... 81  
Theodore (Ted) B. Ray

A Perspective on the Navy's Environmental Management  
Program..... 87  
Paul R. Rakowski

CONTENTS (continued)

The Wisconsin Nonpoint Source Water Pollution Abatement Program.....	99
Bruce J. Baker	
Interstate and Federal-State Institutions for Managing The Chesapeake Bay .....	109
Margaret R. Johnston	
Measuring Progress in the Endeavor of Improving the Quality of Water Within and Received by the Chesapeake Bay.....	121
Waldon R. Kerns	
Responsibilities of Individuals, Business, Industry, and Government for Improving the Quality of Water in the Chesapeake Bay and the Bay's Service-Providing Capacity .....	127
J. Paxton Marshall	
Legislation and Water Quality.....	135
John Cairns, Jr.	

## PREFACE

The Chesapeake Bay is recognized as an important natural resource. However, the continued productivity of this bay is constrained by the inflow of many land-originated pollutants. Recent scientific and management studies indicate that land use is and will remain central to the well-being of the Chesapeake Bay.

Population growth and its associated commercial, and industrial development has often caused land use to shift from environmentally beneficial uses to more polluting uses. These shifts in land use increase wastewater flows and surface runoff of pollutants. Runoff of nutrients, sediments, and toxic materials from both agricultural and urban areas has added to the decreased productivity of the bay.

The goal of this conference on increasing the Chesapeake Bay's productivity by improving land-use management was to improve understanding of the need to adopt, on both an individual and a collective level, improved land-use management practices designed to improve the service-providing capacity of the bay. The conference was designed to enable participants:

- to learn about the relationship between quality of water and the productivity of the Chesapeake Bay's service-providing capacity,
- to understand how increasing Chesapeake Bay's service-providing capacity can contribute to the Commonwealth's economy,
- to understand the effects that individual and collective actions can have on Chesapeake Bay's service-providing capacity,
- to become informed about how institutions may be redesigned or established for the purpose of increasing water quality in Chesapeake Bay and the its service-providing capacity, and
- to learn about alternative actions that can be taken by individuals, business and industry, and government to improve the quality of water Chesapeake Bay receives and contains.

Fifteen papers from the conference are included in these proceedings. Papers by Mackiernan, Gilliam and Skaggs, Hawkins,

Phipps, and Forney and Foy describe some of the pollutants and the ultimate impact of those pollutants on the productivity of the waters in the Chesapeake. Papers by Crafton, Cox, Epp, Ray, Rakowski, and Baker either suggest some specific approaches to management of land-use activities or describe an ongoing program for management of specific pollution sources. Papers by Johnston, Kerns, and Marshall focus on some of the institutional and ethical issues associated with management of land-based pollution activities. The final paper by Professor John Cairns focuses on recent activities in the legislative arena and the potential impact of the decisionmaking process on understanding and managing water quality.

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J. Paxton Marshall  
Waldon R. Kerns  
Professors

Department of Agricultural Economics  
September 1985

## SOURCES AND IMPACTS OF NUTRIENTS IN THE CHESAPEAKE BAY

By Gail B. Mackiernan\*

The Chesapeake Bay system is dynamic and variable. The impacts created by human activity operate against a background of natural climatic cycles and episodic events such as hurricanes, as well as normal daily and seasonal variation. In addition, the bay has been changing throughout its history, although many of these changes have accelerated since European settlement. Awareness of this long-term history of the bay is needed to identify and predict effects of human intervention.

### Historic Changes in Land Use and Pollution Loads

Our time line begins in 1600, near the time of the first permanent settlement in Jamestown (figure 1). Baywide population at that time was estimated to be in the range of ten- to fifteen-thousand native Americans. From that time, population increased rapidly, as can be seen from maps of the period. It is important to realize that major land-use changes also were well underway by the mid-1700s. Forests were being converted to fields, as indicated by the oak/ragweed pollen ratios in sediment cores (Brush and Davis, 1982). Much of the land was then used for tobacco and general agriculture. At the beginning of this period, sedimentation rates were relatively low, sensitive submerged vegetation species were abundant, and phytoplankton communities were dominated by clear water forms (Brush and Davis, 1982).

From about 1800 onward, there was a rapid trend of conversion of forests into fields. This was apparently accompanied by considerable erosion and siltation. Analysis of cores indicate that as sedimentation rates increased, sensitive submerged aquatic vegetation (SAV) species declined in abundance and that there was a general decrease in all types of diatoms (Brush and Davis, 1982). Many early ports, such as Joppatown on Maryland's Gunpowder River, and Bladensburg, on Maryland's Anacostia River, became silted in, and eventually completely landlocked.

Deforestation also apparently lead to a more "flashy" hydrograph, as the stabilization of vegetated cover was lost. Peak flows in rivers may have increased by as much as 30 percent in the past 200 years (Biggs 1981). Higher salinities in the past are reflected in foraminiferal and mollusc remains in cores (Biggs, 1981; Nichols et al., 1982).

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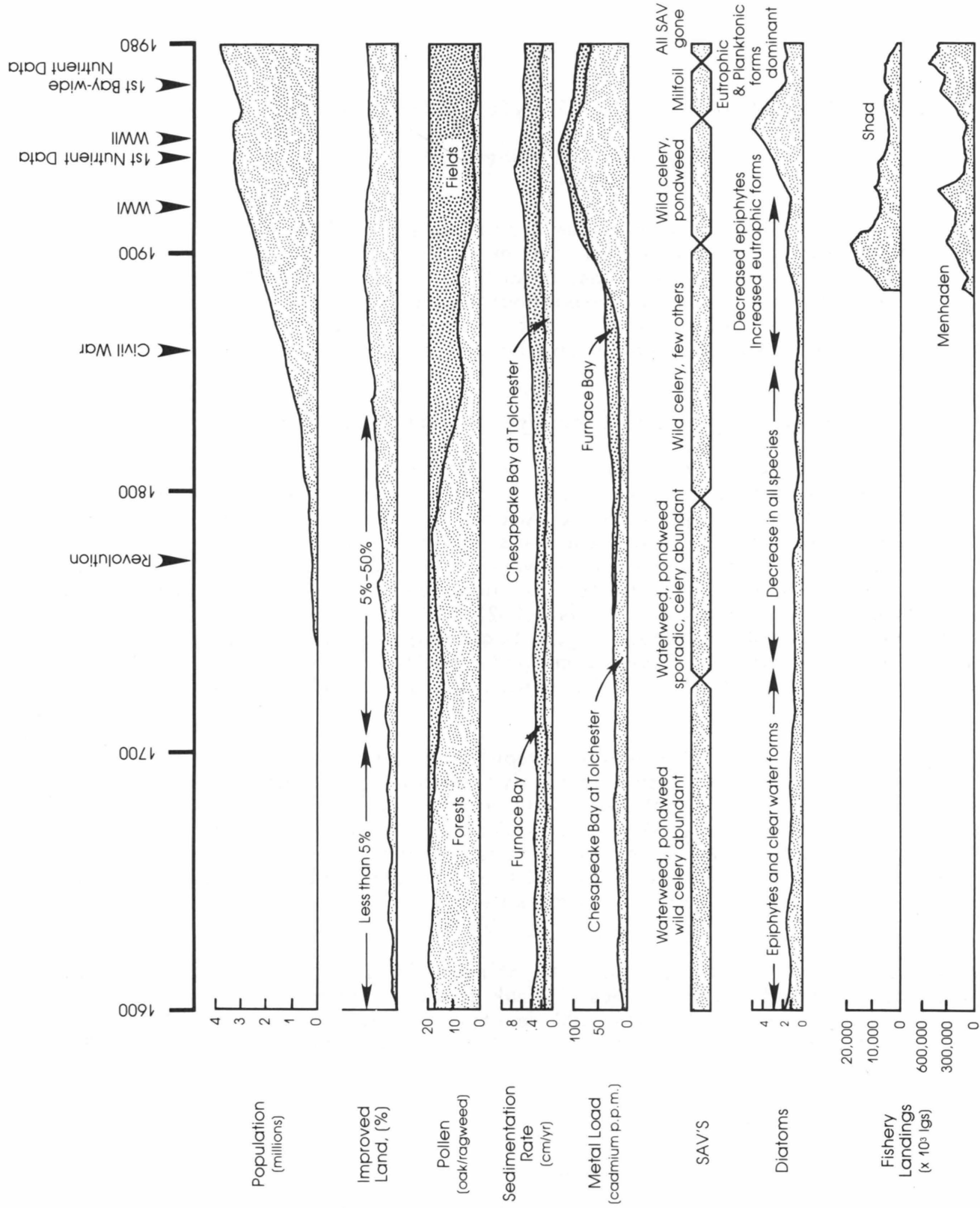


FIGURE 1. TIME HISTORY OF NORTHERN CHESAPEAKE BAY, 1600 to 1980. An important aspect of understanding how Chesapeake Bay will respond to pollution is to examine the Bay's past. In the northern Bay, human activity, beginning at the top of the chart with population growth, has been changing water quality since the time line began.

A growing population placed other stresses on the bay. Rapidly increasing levels of toxic metals in the sediment indicate the onset of the industrial revolution (Helz et al., 1981; Flemer et al., 1983). Inputs of nutrients from sewage also was increasing at this stage; most was, of course, untreated. A marked increase in abundance of planktonic and eutrophic diatom species shows that nutrient enrichment was starting to occur (Brush and Davis, 1982).

During the present era, the prevalence of less sensitive species of submerged vegetation (such as Eurasian watermilfoil) in the stratigraphic record, as well as dominance of phytoplankton, are both indicators of nutrient enrichment (Brush and Davis, 1982). Against these biological indicators, these facts emerge: The first nutrient data from the bay dates from the late 1930s; and the first comprehensive baywide nutrient survey did not take place until 1964. Thus, considerable alteration had taken place in the Chesapeake Bay's system before the existence of sufficient scientific information to evaluate changes.

Nevertheless, even in this short time-window, researchers have been able to detect further alteration in the bay's environment. The past 40 years have been a time of many new events, including accelerated development, industrial expansion, inputs of exotic pollutants, more intensive agricultural activity, and more extensive and sophisticated commercial and recreational fishing. This degree of change makes it difficult to separate and identify specific causes for observed effects, not to mention determining those impacts that are due to anthropogenic activity alone.

For that reason, the Chesapeake Bay Program (CBP) found it most profitable to first develop hypothetical links between observed water quality trends and ecosystem responses and, then, to examine the available evidence supporting each of these hypotheses.

#### Sources of Nutrients to the Bay

Concern for the well being of the Chesapeake Bay prompted Congress to direct the U. S. Environmental Protection Agency (EPA): (a) to conduct a five-year study of the bay's water quality and resources; and (b) to develop management strategies to preserve the bay's health and productivity.

As a first step, concerned groups met and identified the major perceived environmental problems of the bay. Of the initial list, three deemed of critical importance were chosen for intensive investigation: nutrient enrichment, toxic substances, and decline of submerged aquatic vegetation (SAV). Almost 50 CBP research and survey projects focused on these topics. Many of the final results were not originally anticipated.

The CBP examined in detail the sources of nutrients (in this case, phosphorus and nitrogen) to the bay, and the relative contribution of sources under different conditions. The projects supported during this phase included intensive watershed studies; identification and characterization of point source discharges; collection, examination, and analysis of historical nutrient data; land-use inventory; fall-line modeling; modeling of loadings; and evaluation of nutrient control strategies (EPA, 1982; Tippie et al., 1983).

Nutrient inputs to the bay include point (discrete) and nonpoint (diffuse) sources. Sewage treatment plants (POTW) represent the major point source; although another important input in some basins is industrial wastewater. Population growth and increased urbanization influence the relative importance of point sources in each basin in the bay watershed. Nonpoint sources include runoff from agricultural, urban, and forest lands, baseflow to streams (groundwater) and atmospheric deposition (EPA, 1982). The importance of nonpoint sources is greatly influenced by land-use patterns, as well as precipitation. In wet years, the relative contribution of nonpoint sources increases, while it is reduced in dry periods. In addition, inputs from nonpoint sources may vary seasonally, in response to rainfall events or agricultural practices, while POTW loadings represent relatively constant flows.

### Nutrient Loadings

The Chesapeake Bay Program estimated present (1980) and future (2000) nutrient loadings delivered to the bay from throughout its drainage basin (Tippie et al., 1983). The fraction of nutrient loadings originating from point sources and nonpoint sources (in particular from agricultural and urban runoff) were also determined. In general, the nitrogen entering bay waters is contributed primarily by nonpoint sources which are dominated by cropland runoff loadings. Point sources, on the other hand, and especially sewage treatment plants, are the major source of phosphorus to Chesapeake Bay, with the exception of wet years (table 1).

Table 1.--Bay-wide nutrient loadings (March to October) under dry, average and wet conditions

---

<u>Item</u>	<u>Phosphorus</u>		<u>Nitrogen</u>	
	<u>Point</u>	<u>Nonpoint</u>	<u>Point</u>	<u>Nonpoint</u>
	----- Percent -----			
Dry year	69	31	38	62
Average year	61	39	33	67
Wet year	36	64	19	81

---

Source: U. S. Environmental Protection Agency's Chesapeake Bay Program (1982).

Basin-wide, point sources contribute about 33 percent of the total nitrogen load to the bay. However, point sources contribute a larger share of the phosphorus load, averaging 61 percent. Nonpoint sources contribute the difference in the nitrogen and phosphorus loads, making up 67 percent and 39 percent of the total loads, respectively. Most of the nitrogen entering Chesapeake Bay waters have been transported from watersheds throughout the bay basin; phosphorus loadings originate mostly from sources adjacent to the bay (that is, from below the fall line) (Hartigan et al., 1983; Tippie et al., 1983).

The three largest tributaries of the bay, the Susquehanna River, the Potomac River, and the James River, carry most of the nitrogen (78 percent) and phosphorus (70 percent) loads that enter the tidal waters of Chesapeake Bay (figure 2). Although the West Chesapeake basin, centered near Baltimore, is not a large land area compared to other basins, it contributes significant amounts of nutrients to the bay. The Eastern Shore and the Patuxent River, Rappahannock River, and York River basins contribute the smallest portion of the baywide nutrient loads.

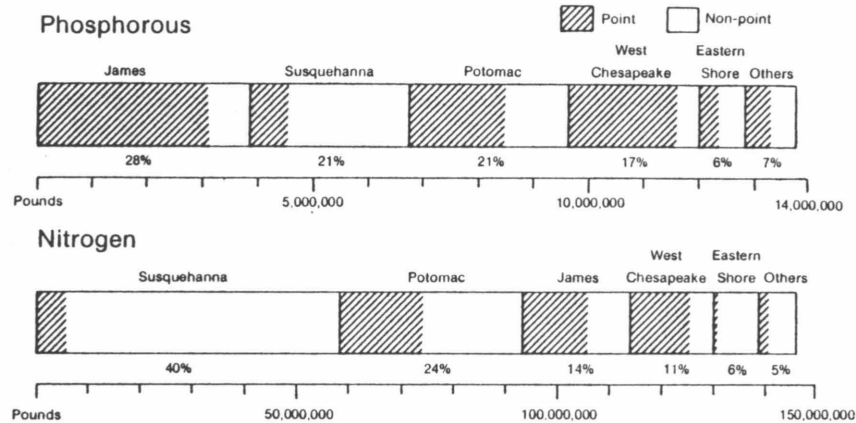


Figure 2. Nutrient loadings (March to October) by major basin under average rainfall conditions.

Nutrient Loadings by Major River Basin--To link loadings of nutrients with specific areas where nutrient and dissolved oxygen concentrations potentially limit aquatic resources, it is necessary to understand the relative contributions of point and nonpoint sources by major river basins. To do this, it is also necessary to determine inputs in dry, average, and wet years.

Phosphorous--Analysis by a numerical model demonstrated that point source loads of phosphorus exceed the nonpoint source loads from the Potomac River and James River basins in almost all rainfall conditions (Hartigan et al., 1983). In contrast, nonpoint sources contribute most of the phosphorus from the Susquehanna River basin under all conditions. This finding reflects the fact that the James River and Potomac River basins contain major population centers that contribute large point source loadings to tidal waters. In the urbanized Patuxent River and West Chesapeake basins, the phosphorus loadings from point sources exceed those from nonpoint sources; however in the largely rural Eastern Shore, and Rappahannock River and York River basins, nonpoint contributions are always the dominant source of phosphorus.

Nitrogen--Nitrogen loadings from the major river basins are more often dominated by nonpoint sources than are phosphorus loadings. In the Susquehanna River and Potomac River basins, nonpoint sources provide most of the nitrogen under all hydrologic conditions. However, below the fall line, nitrogen inputs to the Potomac are dominated by point sources. Most of the nitrogen load in the James River comes from point sources, but, nonpoint sources become important in a wet year. Point source loads of nitrogen always exceed nonpoint sources in the West Chesapeake; however, in the Patuxent River basin, point sources of nitrogen are only dominant under dry conditions. Loadings of nitrogen from the Eastern Shore, and the Rappahannock River and York River basins, originate primarily from nonpoint sources, as do loadings of phosphorus.

Table 2.--Percentages of nitrogen and phosphorus contributions to the Chesapeake Bay by the eight major basins, by point and nonpoint source, and by dry, average, and wet years (March-October)

Basin	<u>Point sources</u>			<u>Cropland</u>			<u>Other</u>			<u>Total</u>		
	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet	Dry	Avg.	Wet
-----Nitrogen-----												
Susquehanna	10	10	5	--	85	91	--	5	4	90	90	95
Patuxent	61	49	26	--	43	66	--	8	8	39	51	74
Potomac	48	44	28	--	48	66	--	8	6	52	55	72
Rappahannock	17	13	7	--	72	84	--	15	9	83	87	93
York	22	13	7	--	77	87	--	10	6	78	87	93
James	71	62	43	--	29	49	--	9	8	29	38	57
W. Chesapeake	85	72	52	--	20	40	--	8	8	15	28	48
Eastern Shore	<u>13</u>	<u>10</u>	<u>4</u>	--	<u>83</u>	<u>92</u>	--	<u>7</u>	<u>4</u>	<u>87</u>	<u>90</u>	<u>96</u>
Total	38	33	19	--	60	75	--	7	6	62	67	81
-----Phosphorus-----												
Susquehanna	24	23	12	--	60	77	--	17	11	76	77	88
Patuxent	88	83	58	--	10	33	--	7	9	12	17	42
Potomac	67	59	34	--	23	50	--	18	16	33	41	66
Rappahannock	47	39	14	--	39	71	--	22	15	53	61	86
York	50	35	10	--	44	76	--	6	14	50	65	90
James	86	81	63	--	12	29	--	7	8	14	19	37
W. Chesapeake	93	85	67	--	8	25	--	7	8	7	15	23
Eastern Shore	<u>44</u>	<u>40</u>	<u>16</u>	--	<u>50</u>	<u>79</u>	--	<u>10</u>	<u>5</u>	<u>56</u>	<u>60</u>	<u>84</u>
Total	69	61	36	--	27	53	--	12	11	31	39	64

Source: Chesapeake Bay Program, U. S. Environmental Protection Agency, (Tippie et al. 1983).

### Sources

Of the point sources, sewage treatment plants contribute the majority of the load of both phosphorus and nitrogen in virtually all cases. However, in relatively undeveloped basins, or in basins with heavy concentration of industry, industrial inputs can be significant.

Of the nonpoint sources, cropland contributes the largest share of the nutrient load basinwide (table 2). This is true for both phosphorus and nitrogen, although the proportion of nitrogen contributed by cropland is greater than that of phosphorus. The importance of cropland reflects both its relatively high per-acre loadings and the large areas of the basin devoted to agricultural lands. Other sources, for example, runoff from forest, pasture, or urban lands, contribute only 11 to 12 percent of the phosphorus load and 6 to 7 percent of the nitrogen load basinwide. Locally, inputs from urban runoff can be significant in reduction of water quality. However, because only 3 percent of the land in the entire basin is considered true urban land, the total baywide loads are small. The proportion of urban and residential land has increased 150 percent since 1950 and can be expected to continue to grow. One aspect of urban runoff that relates directly to impacts on living resources, however, is that many of the largest metropolitan areas are located close to critical resource habitat, such as fish spawning and nursery grounds.

A closer look at nutrient contributions relative to the type of land use, shows that cropland in general has the highest unit loadings (measured in pounds per acre per year) for sediment, nitrogen, and phosphorus (table 3). However, the ranges are very large and the overlap reflects regional differences in soil type, topography, farming practices, and other factors. The most intensive urban uses can yield more nutrients per unit than well-managed, low-tillage cropland on pervious soils.

FIG 3

Table 3.--Nutrient loading by land-use type in the Chesapeake Basin

<u>Land-use</u>	<u>Percentage in basin</u>		<u>Loading rate (lbs./ac./yr.)*</u>	
	Percent	Total N	Total P	
Cropland	15-20	8-18	1.5-5	
Pasture	8-12	2-6	.3-.5	
Forest	60-65	.5-2	.05-.1	
Urban/Suburban	3-5	4-10	1-2	

\*Estimated

Source: U. S. Environmental Protection Agency, Chesapeake Bay Program (1982).

### Nutrient Status and Trends

When the amount of plant nutrients delivered to a body of water increase, the first and most obvious response is often an increase in phytoplankton growth and biomass. In flowing-water systems, physical dispersion may prevent buildup of algae standing-crop. Grazing by herbivores can also reduce phytoplankton biomass. This buildup of organic matter, algae cells, detritus, and zooplankton fecal material, can produce an oxygen demand in affected waters, because of algal respiration and bacterial oxidation of organic material. Therefore, nutrient increases can be expected to be accompanied by elevated chlorophyll values or reduced oxygen levels.

Available nutrient data, as well as data on chlorophylla concentrations, dissolved oxygen, and turbidity, were analyzed to determine present water quality status as well as statistically significant trends over time (Flemer et al., 1983). The relative short history and paucity of data often hampered this analysis. Nevertheless, some interesting general statements can be made.

If the most recent data are examined (1977-1980), the following assessment can be made: The upper- and mid-bay, upper western shore tributaries, tidal-fresh reaches, and some riverine estuarine transition zones of major tributaries have the highest concentration of total nitrogen, while highest levels of total phosphorus occur in the upper reaches of western shore tributaries. Water quality (relative to nutrients) generally improves downestuary and downriver. Eastern embayments and the small western shore tributaries south of the Patapsco River also have relatively low nutrient concentrations. Few data exist for the Virginia main-bay segments; however, most observations show low nutrient concentrations. These low concentrations reflect exchange with the ocean, as well as the progressive reduction of nutrients downestuary through biological utilization and subsequent deposition of sediments.

Chlorophyll concentrations, a measure of phytoplankton biomass, have a pattern similar to that of nutrients: higher in the upper bay, tidal-fresh, and transition areas of major tributaries, and in certain smaller western shore tributaries. Summer chlorophyll levels are typically higher than in spring, except in the mid- and lower-bay which shows a pronounced spring bloom pattern.

Analysis of spring and summer turbidity and Secchidisk measurements taken since 1960 in the tidal-fresh and lower estuarine portions of the major western tributaries and upper- and mid-main bay segments does not reveal any consistent trend in water clarity from year to year. The data are admittedly sparse. However, there does appear to be a recent change in seasonal water clarity. For the most part, pre-1972 measurements indicate that more turbid conditions exist in spring than summer. However, more recent measurements and Secchidisk measurements indicate more turbid conditions in summer than spring. The increased turbidity in summer waters may reflect increased algal growth, reducing water clarity and light transmission.

Tidal-fresh areas are generally more turbid than lower estuarine areas. The tidal-fresh Patuxent was the most turbid; the lower Potomac was the least turbid of all areas examined. There are very little data about the Rappahannock River and York River.

### Nutrient Trends

Nutrient trends were examined for increases or decreases over the period of record (Flemer et al., 1983). Most data on nitrogen and phosphorus distribution began in 1964 with a few studies occurring in the late 1930s (Newcombe and Brust, 1940; Newcombe and Lang, 1939; Nash, 1947). Chlorophyll<sub>a</sub> (uncorrected for decomposition products), an index of phytoplankton standing-crop, is included in this assessment. The earliest data on chlorophyll<sub>a</sub> were collected in the 1950s.

Trends in nitrogen and phosphorus were evaluated to see if any form of these nutrients showed a statistically significant change over time at an alpha level equal to, or less than 0.05, using Pearson correlation (Flemer et al., 1983). This simple screening approach was judged to be a useful starting point but, as discussed later, a more meaningful assessment requires an estimate of the total nutrients (that is, total nitrogen and total phosphorus). A case can be made for the inclusion of silica, a key constituent of diatoms, in the trend assessment. However, historical data are poorly represented in the data base (D'Elia et al., 1983).

Increasing seasonal or annual trends in various fractions of nitrogen or phosphorus are occurring in many areas of the bay. However, it should be emphasized that data on total N and P (the best indicators of nutrient enrichment) are scattered and that increasing trends in one form of nutrient may not mean an overall increase in the total fraction.

Because of the scattered nature of the nutrient trend data, it is helpful to look at a parameter which integrates ecosystem response--in this case, the chlorophyll<sub>a</sub> measure of algal biomass. Where sufficient data exist, it can be seen that most areas of the bay are exhibiting increasing concentrations of chlorophyll<sub>a</sub>, at least seasonally. Another general trend noted by CBP studies was an increase over time in spring chlorophyll levels in the upper- and mid-bay segments (Flemer et al., 1983).

The CBP also examined trends in dissolved oxygen (DO). That an annual cycle of oxygen concentration occurs in many bay waters deeper than about 10 meters has been known for many years (Taft et al., 1980). During winter this lower layer is well oxygenated, but the normal reduction in water-mixing rates, which occurs in spring and summer, results in oxygen being used faster in the deep water than it is replenished from the atmosphere.

The result is oxygen depletion to levels that will not support typical bay biota. There appears to be a change in this normal cyclic behavior, based on oxygen data collected by the Chesapeake Bay Institute over a period of 30 years. The volume of water with DO concentrations equal to or less than  $0.7 \text{ mg L}^{-1}$  ( $0.5 \text{ ml L}^{-1}$ ) was 15 times greater in 1980 than in 1950 (Flemer et al., 1983). On a baywide basis, oxygen depletion seems to be increasing over time. Although such depletion occurred in the 1930s, available data indicate it was of brief duration. In the mid-1950s, it was sporadic in intensity and extent. In the 1960s, oxygen depletion occurred from mid-June to mid-August for each year recorded, with relatively complete data. During the 1970s, duration and extent of low DO generally continued to increase. In 1980, low DO began during the first week of May and continued into September. In addition, the presence of hydrogen sulfide, an indicator of complete anoxia, has been observed more frequently in the 1970s and 1980s than previously. This trend could result from increased organic material

in the deep layer which was available to consume oxygen during its degradation, or from lower DO concentrations in the surface layer that influence the oxygen gradient, or from both (Flemer et al., 1983; Officer et al., 1984). The DO data were examined to see if the trend would likely result from antecedent conditions of wind and tides. The tentative conclusion is that the observed concentrations of DO are not strongly related to the antecedent conditions of wind and tide, but are the result of increasing nutrient loads, coupled with normal conditions of water column stratification and benthic respiration (Flemer et al., 1983; Officer et al., 1984).

### Impacts on Biota

There are a number of hypothetical impacts of increasing nutrients on living components of the bay ecosystem. It is admittedly difficult to demonstrate unequivocal cause and effect; the estuarine environment is naturally variable, and separating the anthropogenic "signal" from the background "noise" is not always possible. Nevertheless, this hypothesis framing allows researchers and managers to focus on areas where effects could be expected and where monitoring or research efforts may yield the most useful information.

The status of the bay's living resources was examined, and the following major trends were identified (Flemer et al., 1983):

- \* In the upper bay, an increasing number of blue-green algal or dinoflagellate blooms has been observed in recent years. In fact, it is estimated that cell counts have increased approximately 250-fold since the 1950s. In contrast, the algal populations in the upper Potomac River have become more diverse since nutrient controls were imposed in the 1960s and early 1970s, with the notable exception of the summers of 1983 and 1984.
- \* Since the late 1960s, submerged aquatic vegetation has declined in abundance and diversity throughout the bay. The decline is most dramatic in the upper bay and western shore tributaries. An analysis over time indicates that the loss has moved progressively downstream, and that present populations are mostly limited to the lower estuary and other areas not considered nutrient enriched (Orth et al., 1983).
- \* Landings of freshwater-spawning fish such as shad and alewife have decreased, especially since 1973. Harvests of marine-spawning fish such as menhaden and bluefish have generally remained stable or increased. Recruitment of anadromous and semi-anadromous fish--that is, the hatching success and larval survival of such fish--has also been poor in the last decade.
- \* Oyster harvests have also decreased baywide. Oyster spat set has declined significantly in the past 10 years as compared to previous years, particularly in the upper-bay and westernshore tributaries and some Eastern Shore tributaries such as the Chester River. The decline in oyster harvest has been somewhat offset by recent increases in the harvest of blue crabs, although this may be due to increased fishing effort. There also has been increased incidence of oyster mortalities in the Maryland portion of the bay in the last few years.

### Hypothetical Impacts of Nutrient Enrichment

Increases in levels of phosphorus and nitrogen may increase standing crops of phytoplankton (Heinle et al., 1980). Provided the phytoplankton species composition matches nutritional requirements of larvae of commercial species (or zooplankton which feed these species), this early stage of eutrophication may actually benefit productivity in portions of the system (Ukeles, 1971). However, as nutrient enrichment progresses, chlorophyll concentrations increase, as do particulate carbon and turbidity. Nutrient enrichment during warmer temperatures results in greater fluctuation in dissolved oxygen concentrations in surface water and in extended periods of near anoxia on bottom water (Heinle et al., 1980; Taft et al., 1980). Effects of these changes could include: shading of SAV by increased phytoplankton or epiphyte growth, leading to decline in SAV abundance (Twilley et al., 1981); and/or organic enrichment of sediments leading to changes in benthic communities such as increased dominance by detritivores (Bascom, 1982).

Shifts in phytoplankton species composition may occur, possibly resulting in blooms of undesirable species (Ryther, 1954). Effects of these changes could include: increased dominance of blue-green algae in tidal-fresh areas or flagellates in saline regions (Thomas, 1972); and/or alteration of biomass and composition of zooplankton or filter-feeding communities, with ultimate impacts on larval fish (Greve and Parsons, 1977) or shellfish (Ryther, 1954).

The extent and duration of low DO in deeper water has apparently increased in recent decades (Taft et al., 1980; Flemer et al., 1983). Impacts of this change could include: elimination of natural benthic community in deeper water (or replacement with ephemeral opportunistic assemblages) (Mountford et al., 1977); and/or decreased habitat for oysters and other commercially important shellfish (Haven et al., 1978). Increased incidence of shellfish mortality at the boundaries of the impacted areas might be expected. Finally, habitat for fish, particularly demersal species such as sciaenids, is reduced; this could be reflected in declines in abundance or condition.

### Response of Living Resources

Submerged Aquatic Vegetation (SAV).--The loss of SAV was one of the major areas addressed by research supported by the Chesapeake Bay Program. For this reason we have a better picture of the factors impacting vegetation and can formulate reasonable causes for the recent declines. The two major anthropogenic factors suggested at the beginning of the program were impact of herbicides and reduction in available light to the plants, as a result of turbidity and epiphyte growth. Studies conducted on both aspects concluded that herbicides represent, at most, a local problem close to the source (Kemp et al., 1982). However, the light limitation research supported the nutrient enrichment hypothesis above. Specifically:

- \* Studies indicate a reduction in the quantity of SAV for the upper- and lower-bay and in the quality of available light. For the growing season, there appears to be a progressive increase in light attenuation (that is, a decrease of light) in the photosynthetically active part of the spectrum (Wetzel et al., 1982).

- \* In situ studies indicate that plant communities in the bay are generally operating under conditions of light limitation.
- \* Decline of SAV over the past several decades has in general followed a "downestuary" pattern, corresponding to a pattern of nutrient enrichment (figure 3).
- \* Microcosm and mesocosm (that is, pond) experiments indicate that nutrient loading leads to a progressive enhancement of phytoplankton biomass, seston, and epiphytes (Twilley et al., 1981).
- \* The combination of water column attenuation and epiphytic shading was sufficient to markedly reduce SAV photosynthesis. Loss of SAV occurred in experimental ponds exposed to highest nutrient loads.
- \* Preliminary evidence suggests that the inability of lightstressed plants to compensate for respiration may lead to reduced energy storage for overwintering and spring regrowth (Twilley et al., 1982).
- \* Reduction of grazers by various natural or anthropogenic perturbations may allow excessive fouling of SAV leaves by periphyton (Orth et al., 1983).

In addition, statistical comparison of SAV abundance with existing water conditions in various sections of the bay showed significant negative correlation with nitrogen, inorganic phosphorous, turbidity, and chlorophylla levels. These observed correlations between SAV abundance and several parameters associated with nutrient enrichment are supported by the strong experimental evidence obtained during the research phase. Such an integrated approach is the most satisfactory means of identifying causative relationships.

Benthic Organisms, including Shellfish.--Increased stress on benthic communities can result in changes in the abundance and structure of these assemblages (Boesch, 1977). For example, sensitive species may be eliminated and resistant forms enhanced. In particular, populations of opportunistic polychaete or oligochaete worms may come to dominate in stressed areas, while relatively sensitive molluscs and crustaceans are reduced in abundance (e.g. Pfitzenmeyer, 1975).

Nutrient enrichment may result in increased organic loads to the sediments, changing their structure and thus altering the type-of benthic organisms found within them. In particular, increased numbers of infaunal detritivores have been associated with organic loading from sewage treatment outfalls (Bascom, 1982). Oxygen depletion, resulting from both bacterial decomposition of organic matter and night-time respiration of algal blooms, is a major factor influencing benthic communities (Pearce et al., 1976; Mearns and Word, 1982). In mid-Chesapeake Bay, summer hypoxia in water below 10 meters depth severely limits distribution and survival of benthic fauna (Holland et al., 1977; Mountford et al., 1977).

For species (such as oysters) which depend on phytoplankton, nutrient enrichment may cause shifts in phytoplankton species to forms less suitable for food (e.g. Ryther, 1954). Eutrophication often results in blooms of types considered less desirable: bluegreens, non-motile greens, and dinoflagellates.

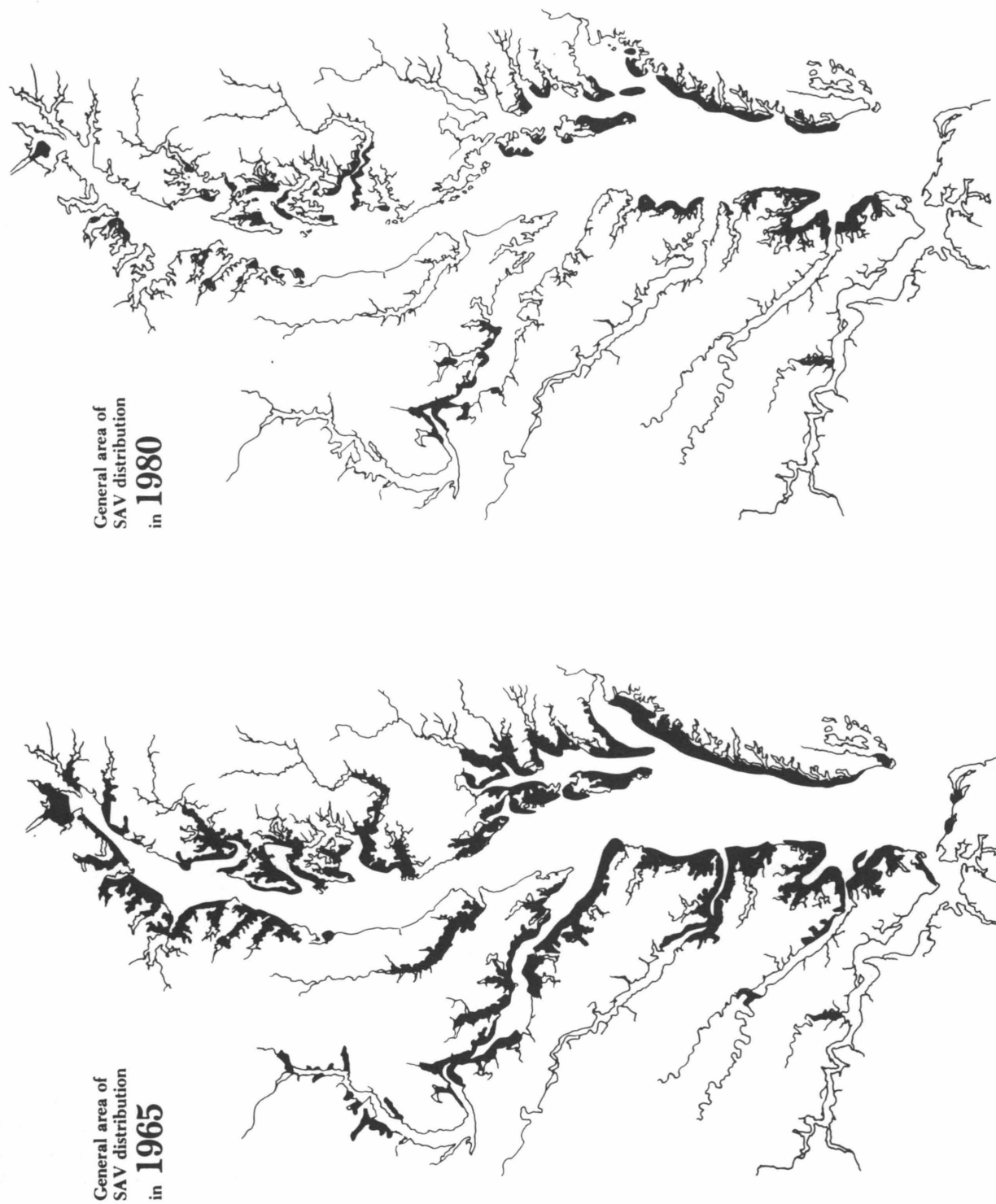


Figure 3. General area of submerged aquatic vegetation distribution.

Examination of available data indicates that nutrient enrichment of the bay affects benthic organisms primarily through an increasing area of low dissolved-oxygen in summer in deeper water. In regions subject to reduced DO, benthic communities may be completely eliminated or replaced by opportunistic assemblages (Holland et al., 1977). As the area impacted by hypoxia increases, summer benthic communities become restricted to the shallower bay margins. This also reduces habitat for bottom-feeding predators, including crabs. Reduction in foraging area might affect abundance, growth, and condition of these predators.

Increasing instances of oyster mortality (measured as the percent of empty shells or "boxes") have been reported for upperbay sites in recent years. One hypothesis is that intrusions of low-oxygen water onto shelf areas occur with greater frequency now because the area impacted by hypoxia has increased.

Additionally, wind events can shift bay surface waters, allowing deep low-oxygen water to intrude onto the shelf. "Crab wars" or "jubilees" can occur when northwest winds persist for hours or days: crabs and other mobile species congregate in the shallows or even move onto the beach, to avoid anoxic conditions (Carpenter and Cargo, 1957).

Interviews with waterman from the mid-bay region support this hypothesis and give insights into possible impacts of low dissolved-oxygen on shellfish harvests (Flemer et al., 1983). Briefly, there has been a progressive reduction in the depth at which crab pots can be set in summer months, loss of condition in crabs potted in August, reduction in oyster harvest from deeper bars, and observations that adult crab are wintering in less deep areas and appear to be avoiding the deep channel. In many areas of the bay, oysters are restricted to depths less than 10 meters by low oxygen-levels (Haven et al. 1980).

Finfish.--Finfish respond to a number of natural and anthropogenic variables, even though their mobility allows them to avoid certain stressful conditions. In particular, climatic factors have a strong effect on spawning success and juvenile survival (Ulanowicz et al., 1981). These responses are so marked that more subtle impacts caused by anthropogenic stress can be masked.

It can be hypothesized that nutrient enrichment can affect finfish in several ways: alteration of phytoplankton-based food webs on which larval and juvenile species depend; reducing available habitat for adults and juveniles of many species, particularly bottom-oriented (demersal) fish because of low DO; interfering with larval transport mechanisms utilizing upstream-flowing deep-water, again because of reduced oxygen levels; and reduction of habitat for forage fish and juvenile fish (and crabs) because of loss of submerged aquatic vegetation.

The correlation of abundance and survival of fresh-water spawning species such as striped bass with the density of zooplankton food organisms indicates the importance of plankton food webs to finfish. (Setzler et al., 1980; Martin et al., 1982). Hypothetically, the shifts in the phytoplankton community to less desirable forms might result in lower zooplankton abundance (Officer and Ryther, 1980). Eutrophication, with associated algal and water quality problems, may be one reason for striped bass failing to use previous spawning areas near Washington, D.C. (Lippson et al., 1979). However, there is little evidence that major changes have occurred in phytoplankton communities in most other bay areas (Flemer et al., 1983). Admittedly, this could be due to the paucity of data.

In the Chowan estuary in North Carolina, researchers are building a case for a nutrient enrichment food-web shift effect on fish (S. Mozley, personal communication). Increased nutrient loading from nonpoint sources has caused proliferation of blue-green algae and in other small forms. A decline in the size and abundance of zooplankton accompanied this trend. A reduction in the growth rate of larval and juvenile blueback herring, which are spawned in the area, has been observed. These results are preliminary, but the observed effects are consistent with the food-chain impact hypothesis.

One major direct impact on finfish, both adults and juveniles, could be observed increases in the extent and duration of hypoxic events. Tolerances of fishes vary with the species, the stage of the life cycle, the level of stress from other factors, the previous history of exposure (acclimation time), the temperature of the water, and other intrinsic and extrinsic factors (EPA 1976). However, a sufficient body of information has been developed to set criteria levels objectively and to suggest the general effects expected at various concentrations of DO. The EPA has established  $5.0 \text{ mg L}^{-1}$  ( $3.6 \text{ ml L}^{-1}$ ) as the minimum concentration necessary to maintain good fish populations. This standard is based principally on freshwater fish (EPA, 1976).

Davis (1975) established minimal DO requirements for fish and other aquatic life in Canada by using an extensive review of available literature. The oxygen criteria for fish are based on oxygen response thresholds for freshwater, marine, and salmonid fishes. The data were statistically treated to normalize the difference in experimental conditions, fish tested, and factors such as temperature (table 4). Briefly, level A represents an oxygen level that assures a high degree of safety for fish stocks, while level C is the concentration where a large proportion of the population may be affected; the impact may be severe if the minimum value is prolonged beyond a few hours.

Table 4.--Suggested level of protection for selected groups of finfish

Group	Protection level	ml $\text{O}_2\text{L}^{-1}$	Range of percent saturation (0-25°C)
Freshwater mixed fish population (no salmonids)	A	3.85	60-66
	B	2.80	47-48
	C	1.75	35-36
Marine, non-anadromous	A	6.13	88-100
	B	4.73	69-98
	C	3.15	50-65
Anadromous marine species: (including salmonids)	A	6.30	100
	B	4.55	79-94
	C	2.80	57-58

Sources: Davis, 1975.

Most Chesapeake Bay species demonstrate behavioral stress, and probably some metabolic stress, when oxygen levels fall below  $3 \text{ ml L}^{-1}$ ; most will die if exposed to concentrations less than  $0.5 \text{ ml L}^{-1}$  (Flemer et al., 1983). Examination of dissolved

oxygen data (collected by the Chesapeake Bay Institute of Johns Hopkins University) from July 1950 to 1980 indicates that a significant volume of the bay waters are now showing these reduced oxygen values (table 5). It would be expected that adult fish would avoid the low-oxygen areas and, thus, they would be confined to shallow margins or surface waters for feeding and spawning.

The fishes and shellfish most likely to be affected by the mid-bay anoxic conditions are those that are primarily benthic feeders (e.g., spot, croaker, and channel catfish), bay spawners that spawn in mid-late summer (e.g., bay anchovy, Atlantic silversides, and weakfish), and benthic dwellers (e.g., blue crab, soft clam, and the oyster) (table 6). Of the species mentioned as examples, all have shown declines in the last decade except for the blue crabs and weakfish.

Table 5.--Volume of water affected by reduced oxygen (expressed in millions of cubic meters and as estimated percent of aquatic habitat affected)

Dissolved oxygen concentration (ml L <sup>-1</sup> )	July 1950		July 1980	
	m <sup>3</sup> x 10 <sup>6</sup>	Percent	m <sup>3</sup> x 10 <sup>6</sup>	Percent
0.5	294	1	4294	19
1.0	1366	6	6444	28
2.0	6445	28	10680	46
3.0	10702	45	13488	59

Source: Flemer et al, 1983.

Table 6.--Period of utilization of deep water by ecologically and commercially important species of finfish and blue crabs

Adult winter flounder	November - May
Adult summer flounder	April - November
Adult and juvenile striped bass	October - March
Adult and juvenile white perch	November - March
Gizzard shad	November - April
Spot	April - October
juvenile	March - May
Atlantic croaker	March - November
juvenile	September - April
Silver perch	June - October
Black and red drum	June - October
Bay anchovy, adult and juvenile	November - April
Atlantic silversides	Only during coldest weather
Male blue crabs (upper, mid-bay)	October - April
Female blue crabs (lower bay)	October - April
Menhaden, post larvae	January - March
pre-juvenile and juveniles	March - October

Sources: Flemer et al., 1983.

### Conclusion

As anticipated in the introduction of this paper, there is considerable difficulty in demonstrating unequivocal "cause and effect" between changes in environmental quality and trends in living resources. At best, we can show evidence that supports reasonable hypotheses as to potential effects. In some cases, results of research or monitoring performed under relatively controlled conditions have made the cases stronger and more compelling.

The evidence available indicates that nutrient enrichment has altered the Chesapeake Bay environment, and that this has had direct and indirect effects on the bay's living resources. Furthermore, it is apparent that the diverse sources of these nutrients call for integrated and well-planned control strategies if we are to maintain and restore environmental quality.

The bay ecosystem is not amenable to exact solutions because uncertainty always will surround the causes of problems. The Chesapeake Bay Program anticipates that future research and monitoring will continue to reduce uncertainty. Prudent management cannot wait for science to provide a precise level of assurance or run the risk of the "ultimate experiment." It is contemplated that a coherent approach to problem identification and probable cause will yield dividends in spite of our acknowledged uncertainties (Flemer et al., 1983).

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MANAGEMENT OF AGRICULTURAL DRAINAGE WATER  
TO MINIMIZE NUTRIENT INPUTS TO ESTUARIES AND BAYS

By J. W. Gilliam and R. W. Skaggs\*

There is no question that land use and land management affects the quality of the water draining from any parcel of land. The generally accepted standard for drainage water from land is the quality of water that drains from land in native forest that is not being actively logged. This is our goal for all drainage water from land. This standard represents background water quality.

Although the quality of water draining from agricultural or forested land is relatively good, the total quantity of nutrients entering an estuary from these sources is quite large. Consider, for example, the Chowan River in northeastern North Carolina which has over 75 percent of its watershed in Virginia. This river has experienced severe water quality problems in the form of algae blooms caused by high nutrient concentrations. Estimates indicate that most of the nitrogen (N) and phosphorus (P) in this river comes from agriculture and forestry, table 1.

Table 1.--Estimated input of nitrogen and phosphorus to the Chowan River

Sources	Nitrogen		Phosphorus	
	Pounds ac/yr	Percent of total	Pounds ac/yr	Percent of total
Agriculture	6	48	0.8	32
Forest	2	47	0.4	47
Total		95		79

Source: North Carolina Department of Natural Resources and Community Development (1979)

Piedmont Agricultural Drainage Water

In the Virginia Piedmont, there does not seem to be much difference in the quality of water draining from watersheds that are almost exclusively forested and

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those that contain a substantial amount of row crops and pasture. This is illustrated in the data from the drainage basin of the Meherrin and Nottoway Rivers, table 2. Water quality from the North Carolina Piedmont is similar.

Table 2.--Nitrogen and phosphorus concentrations in the drainage water of three agricultural and four silvicultural Virginia Piedmont watersheds

Item	Unit	Forested	Agricultural
Forested	Percent	86.0	55.0
Agricultural	Percent	13.0	43.0
NO <sub>3</sub> -N	mg/l	0.03	0.12
TKN	mg/l	1.40	1.38
Total N	mg/l	1.43	1.50
Total P	mg/l	0.07	0.18

Source: Humenik et al., 1980

Several factors lead us to believe that a change in agricultural practices in the piedmont is not likely to improve the quality of the water entering the coastal bays or estuaries. Among these factors are: (1) the relatively small increase in nutrient concentrations from agricultural land as compared to background, and (2) piedmont soils are located sufficiently far from an estuary or bay that the assimilative capacity of the stream would tend to mask any improvement in nutrient water quality at the field's edge. However, the use of recommended agricultural practices, such as minimum tillage, should be encouraged for the purpose of improving upstream water quality.

#### Coastal Plain Agricultural Drainage Water

The potential contribution of fertilizer nutrients applied on coastal plain soils to water quality problems in the bay is much greater than the threat from the piedmont. Several factors are responsible. One of the most significant is that the concentration of nitrogen and dissolved phosphorus in the drainage water from agricultural fields tends to be higher in the coastal plain than in the piedmont. This is the case even though erosion is much less of a problem in the coastal plain. However, a much higher percentage of the land area in the coastal plain has been converted to agricultural use with the potential for even greater conversion. Another factor is that the drainage water from the coastal plain has considerably less distance to travel before reaching the bay than that from the piedmont and mountains.

There are many factors which influence the magnitude of the loss of fertilizer nutrients in drainage water from coastal plain agricultural areas. Among these are crops grown, fertilizer rate, soil type, type of drainage, water management, and cultural practices. Losses typical to those measured from Atlantic Coastal Plain watersheds are shown in table 3. The nitrogen losses, in particular, are larger than those reported for the piedmont.

Table 3.--Annual losses (three-year average) of nitrogen and phosphorus in drainage water from two Coastal Plain watersheds in North Carolina

Watershed	Size	Amount cropped	NO <sub>3</sub> -N	TKN	Total N	Total P
	Acres	Percent	----- lb/ac/yr -----			
Soils:						
Well drained	3,000	48	2.2	1.8	4.0	0.14
Poorly drained	17,000	25	0.4	1.8	2.2	0.21

Source: Jacobs and Gilliam, 1983

The data in table 3, on contribution per acre, include all of the forested land in the watershed. If one just considers the contribution from the cropped land, the estimated contribution increases, as shown in table 4.

Table 4.--Estimated contribution of cropped land to the flux of N

Watershed	NO <sub>3</sub> -N	TKN	Total N
	----- lb/ac/yr -----		
Soils:			
Well drained	4.5	2.8	7.4
Poorly drained	1.4	5.5	6.9

Source: Jacobs and Gilliam, 1983

If the entire area of the watersheds were cropped, the total contribution of nitrogen per acre of cultivated land would be larger than that reported in either table 3 or table 4. For example, the average loss in drainage water of NO<sub>3</sub>-N alone, from four representative fields in the well-drained soil watershed included in these tables, was 29 lb/ac/yr. This measurement was made at the field's edge. Since we measured only 4.5 pounds of nitrogen as nitrate per cultivated acre leaving the watershed in the stream, something happened to the other 25 pounds of nitrogen between the field's edge and our measurement station on the stream. Because the fate of this nitrogen has strong implications for future resource management to protect the quality of water in our estuaries and bays, let's examine how this 25 pounds of nitrogen was lost from the drainage water between the field's edge and the watershed stream.

The study area was approximately 50 percent wooded and 50 percent cultivated as is typical of the upper and middle Atlantic Coastal Plain. Most of the wooded area borders agricultural fields and streams so that the drainage water from the fields must pass through the wooded area before entering a larger stream. We found that subsurface drainage water moving from a field and passing through a heavily vegetated riparian buffer area, as narrow as 50 feet next to a natural stream, lost essentially all of its nitrogen as it passed through the buffer area. In

another study by the North Carolina group (Cooper, unpublished data), we have also observed that these riparian areas are also very effective sediment and phosphorus traps. Thus, unintentionally the pattern of agricultural development in much of the coastal plain has left a very important nutrient removal mechanism intact.

The above discussion refers to coastal plain areas that are sufficiently well drained so that they do not require ditches or tile drainage for agricultural usage. However, there are large areas that do require improved drainage. Improving the subsurface drainage for agricultural purposes will nearly always increase the nitrogen concentration in drainage water from the fields. The type of drainage system installed has a large influence upon quantities of nitrogen lost. The highest concentration of nitrogen is nearly always lost through a tile drainage system. Measured losses of 10 to 65 pounds of nitrogen per acre per year moving into surface water through tile lines have been made with the most common measurement being 25 to 40 pounds per acre per year. Open ditches tend to lose less nitrogen because subsurface drainage is not as good, and more nitrogen is lost through denitrification as it enters the ditch. All of this is illustrated in figure 1, which utilizes the data from the well-drained site discussed before. The  $\text{NO}_3\text{-N}$  concentration in the field water is always higher than in the tile lines which is higher than the concentration in the field ditches into which the tile lines discharge. But there are off-setting benefits. While good subsurface drainage provided by tile lines increases nitrate concentration, surface runoff is reduced with a concomitant reduction in phosphorus, sediment, and pesticide outflow.

The two mechanisms affecting nitrate outflow, loss in the riparian zone next to the field and loss during entry into field ditches, explain much of the difference between edge-of-field nitrogen losses and watershed nitrogen losses. The remaining loss is due to denitrification during transport in the stream system and on the floodplain during high discharge periods. Coastal plain swamp-floodplain systems have frequently been given credit for purifying much of the drainage water from agricultural land. They do have the potential to do this. But, in North Carolina most of the purification occurs immediately adjacent to the field, also large swamps have a very low concentration of nutrients in the water entering them. Thus, the low nutrient concentrations in the water leaving the swamp are not a result of purification in the swamp. The above information indicates that improved agricultural drainage systems will increase the nutrient content of drainage water. Many individuals believe that this is bad for water quality in streams and estuaries.

#### Research on Drainage Water Management Systems

Since artificial drainage is essential for agricultural production in much of the coastal plain, research was begun several years ago to find ways of managing the drainage water to minimize any detrimental effects of improved drainage on water quality. Flashboard risers were used as drainage control structures in field outlet ditches in an attempt to increase the quality of the drainage water (Gilliam et al., 1978). The amount of nitrate-nitrogen reaching surface water from tilled agricultural fields could be reduced by approximately 50 percent by using controlled drainage. There also was a reduction of P loss under some conditions.

Skaggs and Gilliam (1981) have computed the effect of drainage system design and operation on nitrate loss from a particular North Carolina coastal plain soil.

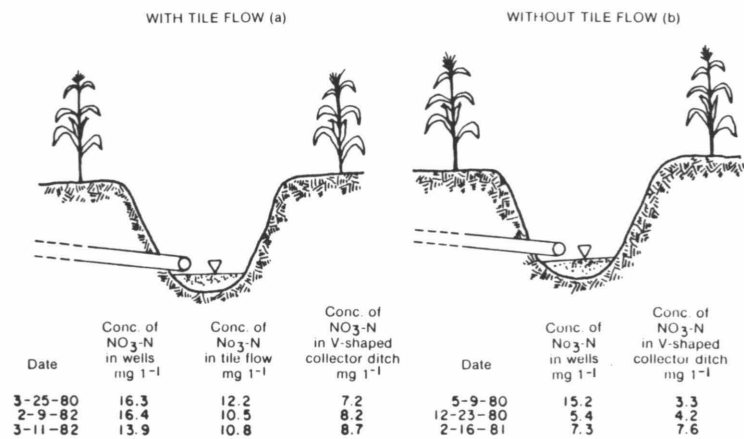


Figure 1. Concentrations of nitrate in soil profile, tile drainage water, and V-shaped collector ditch, (2) with tile drainage effluent and (b) under drier conditions with no tile flow. (From Jacobs and Gilliam, 1983)

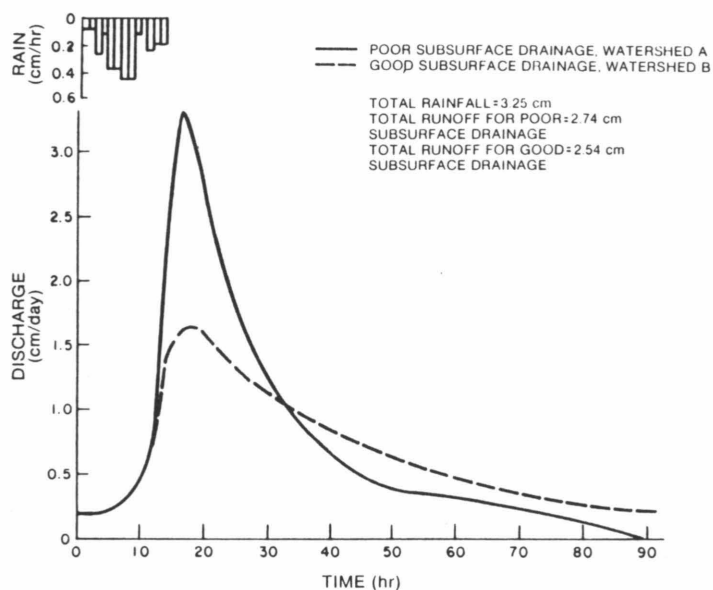


Figure 2. Runoff hydrographs for 3.25 cm rainfall event on Feb. 28, 1983. The peak runoff rate for watershed A with poor subsurface drainage was more than twice that from the adjacent watershed B which had good subsurface drainage.

This computation is shown in table 5. This table shows that, to maintain protection from excessive water, drain spacing must be closer for controlled drainage than for uncontrolled drainage.

Table 5.--Effect of drainage system design and operation on computed NO<sub>3</sub>-N outflow from a North Carolina Coastal Plain soil

Item	Unit	Conventional drainage	Controlled drainage (all year)
Surface drainage:			
Good			
Drain spacing	Feet	90	74
NO <sub>3</sub> -N outflow	Lb/ac	18	10
Poor			
Drain spacing	Feet	55	30
NO <sub>3</sub> -N outflow	Lb/ac	35	35

Source: Skaggs and Gilliam, 1981

At first, it might seem that farmers would be unwilling to install controlled drainage systems because of the extra expense and management required. However, the same system that offers drainage control for water quality also has the potential to conserve some water to be used for crop production. This option was very attractive to farmers who were hit hard by dry weather in 1982 and 1983. The controlled system also has the potential to be used for subirrigation by pumping water into the ditch and letting the drainage system distribute the water back through the field. These combinations have proven so attractive to farmers that numerous flashboard risers are being installed in eastern North Carolina field ditches. The Soil Conservation Service is setting up seven demonstration projects for improved water management through water-table control.

As noted above, the drainage system that minimizes nitrogen outflows from agricultural fields tends to have the opposite effect upon phosphorus outflow. This is illustrated by the unpublished data from two adjacent watersheds with similar soils and identical management, table 6. The only known difference between the two watersheds is that one has good subsurface drainage provided by tile lines and open ditches while the other has poor subsurface drainage so that a larger percentage of the water leaves the site as surface runoff.

Nitrate is lost primarily through subsurface drainage. However, essentially all phosphorus lost from agricultural fields is by surface runoff. Thus, there is a very strong tendency for drainage management practices to have a different effect upon these two important parameters of water quality.

Table 6.--The effect of good subsurface drainage and poor subsurface drainage upon nitrogen and phosphorus concentrations in drainage water from two North Carolina Coastal Plain agricultural watersheds

Watershed	Concentrations		
	NO <sub>3</sub> -N	TKN	Total P
----- mg/l -----			
Subsurface drainage:			
Good	3.8	1.9	0.16
Poor	1.3	1.6	0.08

Freshwater intrusion into estuarine nursery areas has been a primary concern to marine biologists working in the North Carolina estuaries and to area fishermen. Fishermen have been very concerned that improved agricultural drainage will result in a much faster runoff rate from agricultural land near the estuary which could result in widely fluctuating salinity in the nursery areas. Drainage and conversion of swampland to agriculture generally does result in a faster rate of runoff. Skaggs et al. (1980) found that the peak flows from agricultural fields were three to four times greater than peak flows from undeveloped land. However, as illustrated in figure 2 (refer to page 25), the drainage system design can have a larger influence on the rate of runoff from agricultural land. Using the data from the same watersheds discussed in table 6, figure 2 shows that good subsurface drainage greatly reduced the peak runoff rate and spread the drainage period over a longer time. This is because good subsurface drainage lowers the water table, providing more storage for infiltrating rainfall, resulting in less surface runoff.

Another experimental agricultural water management technique that shows considerable promise for both water quality and crop production has generated much interest in the Atlantic Coastal Plain. This technique uses a water control structure in a channelized stream. A structure was installed in Mitchell Creek in eastern North Carolina by the U. S. Department of Agriculture's Agricultural Research Service, in cooperation with the North Carolina Agricultural Research Service. This stream drains approximately 14 square miles of largely agricultural land. Much of the effort devoted to this project involves management for agricultural production but a very significant objective is to improve water quality, if possible.

The currently available tentative data shown in table 7 look promising for water quality considerations. These data are for only one year of control so caution should be applied to their use. However, the data provide a convincing argument that control structures can be used to overcome many of the environmental objections to the channelization of streams. The control structures also are very acceptable to farmers because of increased yields and the potential for using the stored water for irrigation.

Table 7.--Effects of drainage control in a channelized stream upon nitrogen and phosphorus concentrations

Item	Concentration in controlled stream reach					
	NO <sub>3</sub> -N			Phosphorus		
	Entry	Exit	Percent change	Entry	Exit	Percent change
	-----mg/l-----			-----mg/l-----		
Before control	1.87	2.67	+42	0.02	0.06	+200
After control	2.93	2.06	-30	0.06	0.07	+16

### Conclusion

There is no question that nutrient concentrations in drainage water from agricultural land is higher than from forested land. Even so, the nutrients leaving agricultural land in drainage water constitute only a small percentage of the fertilizer added. Nutrient concentrations in the drainage water usually do not represent a large change over background concentrations. However, a small change in the nutrient concentrations coming from many thousands of acres could make a very significant impact upon a bay or estuary. Productive agriculture can be maintained without seriously damaging the estuaries or bays which receive the agricultural drainage water.

The greatest opportunity for management decisions to influence quality of agricultural drainage water before it reaches estuaries or bays is in the coastal plain. In the Atlantic coastal area, the coastal plain is the area where the most intensive agriculture is located. The coastal plain is also closer to the bays and estuaries than the piedmont and mountains; as a consequence, not as much purification of water occurs between the fields and the estuaries.

In the upper coastal plain where artificial drainage is not as essential, riparian vegetation between the field and stream serves very well to purify the agricultural drainage water. Concentrations of nutrients in the streams will almost certainly increase, if these riparian areas are cleared, the natural streams changed to field ditches, and cultivated land covers most of the land area.

In the middle and lower coastal plains, where artificial drainage is essential for agricultural production, there are some exciting new drainage-water management alternatives that show considerable promise for maintaining water quality. These water management techniques appear to be very acceptable to the agricultural sector because they either increase yields or have no effect on yields. Among the agricultural water management techniques that could benefit the quality of bodies of water receiving agricultural drainage water are these:

- (1) Utilization of various combinations of surface and subsurface drainage.
- (2) Utilization of drainage control structures in field ditches.
- (3) Utilization of drainage control structures in large channelized streams.

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## CROP FERTILIZATION THAT WILL REDUCE POLLUTION OF SURFACE WATERS

By George W. Hawkins\*

Nitrogen and phosphorus are plant nutrients applied as fertilizers to various crops. Nitrogen and phosphorus react in quite different ways with the soils to which they are applied. As a consequence, different management practices can be used to reduce the amount of nitrogen and phosphorus lost from cropland. These practices can be placed in three categories: (1) those concerned with rates of application, (2) those concerned with time and method of application, and (3) those concerned with retaining the nutrient on the field to which an application has been made. Time and methods of application that are optimum for both crop management and pollution abatement differ significantly. Thus, the discussion can be simplified if each nutrient is discussed separately.

### Nitrogen

Rate of Application.--The usual criterion for judging whether application rates of nitrogen are too high or too low is the economics of nitrogen use, that is, whether or not the amount applied is producing maximum net profit. Profitability is determined by the size of yield increase obtained from nitrogen application in relation to an expected price of the crop being produced, say corn. Both soil and climatic factors interact to determine what the yield increase will be in a particular field in a given year. At present, we do not have predictive models that make it possible to calculate the optimum rate of application based on nitrogen cost-corn price relationships. This does not mean we are totally without insight as to what these rates should be.

Crop-response-to-nitrogen-application data obtained from research conducted by the state agricultural experiment stations give information one can use to plan application rates. Data shown in table 1 are typical. These data show corn response to different applications of nitrogen when grown on three different soils in Virginia. The differences are clear. First, the maximum yields were not the same for the three soils. Second, these differences in response determine three different optimum rates of nitrogen application.

If one assumes a nitrogen cost of 25 cents per pound and a corn price of \$2.50 per bushel, the optimum rate of nitrogen in pounds per acre is 200 pounds on the Congaree soil, 160 pounds on the Davidson, and 120 lb. on the Cecil. These data show that the productive potential of the soil is an important consideration in determining the rate of nitrogen application. Quite often the yield goal is used as

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a criterion in determining application rates. Obviously if one does not select a realistic goal, the result is an excessive application of nitrogen that aggravates the problem of nitrogen movement into surface water.

Table 1.--Corn response to different rates of nitrogen applications when grown on three different soils in Virginia.

Nitrogen application rates	Soil		
	Congaree	Davidson	Cecil
lb./ac.	bu./ac.		
0	101	65	35
40	133	110	44
80	157	130	50
120	176	140	54
160	190	146	56
200	198	149	56

Source: Virginia Cooperative Extension Service, Virginia State and Virginia Tech, Virginia's Land-grant Universities.

Time of Application.--During the first 35 days after planting, a corn crop takes up only 10 percent of the total nitrogen needed by the crop. Wheat has taken up only 10 percent of its nitrogen requirement when the first node has formed in the stem, i.e., stem elongation has begun. This growth stage may not occur until five months after the crop is planted. The major period of nitrogen uptake by a flue-cured tobacco crop begins approximately three weeks after transplanting. Clearly, applying all the nitrogen needed to produce a crop at the time of planting is not necessary. If the full amount of nitrogen is applied at planting, a significant amount can be lost through leaching and surface runoff. Delaying a major portion of the total application until just before the period of rapid uptake will result in greater recovery of applied nitrogen by the crop. This is illustrated by the data in table 2, taken from research conducted at North Carolina State University. Greater crop utilization of applied nitrogen also has resulted in higher crop yields. This is shown in table 3 by data taken from research conducted at the University of Kentucky.

Producing crops by the no-till method, i.e., the previous crop's residue is left on the surface, reduces surface runoff of water and concomitant loss of soluble fertilizers. However, a reduction in runoff means an increase in the amount of water soaking into the soil and possible increases in the amount of applied nitrogen lost through leaching. This also suggests that delayed nitrogen applications could be particularly important when corn is produced by the no-till method. This is illustrated by the data in table 4. These data are taken from research conducted by Professor V. A. Bandell of the University of Maryland.

Table 2.--The effect of time of nitrogen application on nitrogen uptake by corn, North Carolina, 1969

Time of application	Nitrogen uptake
	lb./ac.
Winter	113
At planting	142
Sidedressing	153

Source: S. Broome, M.S. thesis, N. C. State University, 1969.

Table 3.--The effect of time of nitrogen application on corn yield, Kentucky, 1971

Application rate	Time of application	Yield
lb./ac.		bu./ac.
0	At planting (May 22)	70
150	Sidedressed (June 22)	100
150	At planting (75 lb.)	140
150	Sidedressed (75 lb.)	140

Source: Unpublished data of G. W. Thomas, Agricultural Experiment Station, University of Kentucky, Lexington, Kentucky

Table 4.--The effect of time of nitrogen application on corn yield when grown by the no-till method\*

Time of application	Yield
	bu./ac.
No nitrogen applied	61
120 lb. broadcast and 0 lb. sidedressed	153
60 lb. broadcast and 60 lb. sidedressed	158
30 lb. broadcast and 90 lb. sidedressed	167
0 lb. broadcast and 120 lb. sidedressed	175

\*The broadcast application was made just before the crop was planted. The sidedressed application was made when the corn was about 18 inches high.

Source: Personal communication, V. A. Bandel, University of Maryland.

Yields increased with an increasing portion of the total nitrogen application being made as a sidedressing. Sidedressing as a time and method of application is a practice that will result in more efficient use of the applied nitrogen by the crop and less loss to other segments of the environment.

Nitrification Inhibitor.--Nitrification inhibitors are compounds that, when applied in the soil in the same location as the nitrogen, will inhibit conversion of nitrogen from the ammonium form, to the nitrate form. Keeping nitrogen in the ammonium form for a longer period of time will reduce the amount that can be lost more readily through leaching. When significant loss is possible through these means, and corn is being produced by conventional tillage, use of a nitrification inhibitor will reduce nitrogen loss, increase crop utilization of the applied nitrogen, and increase yields. This is shown by the data in table 5 taken from research conducted by Professor E. J. Kamprath of North Carolina State University.

Table 5.--The effect of rate of nitrogen application and use of a nitrification inhibitor on corn yields\*

Nitrogen application	Yield
lb./ac.	bu./ac.
0	22
50	43
100	47
100 + nitrification inhibitor	97
150	85
200	85

\*The data in table 5 were obtained in research conducted on a deep sandy soil where leaching is a serious problem. Using a nitrification inhibitor with nitrogen applied at planting time can give results similar to those obtained by delaying the application until the corn is approximately 18 inches tall.

Source: Personal communication, E. J. Kamprath, N. C. State University.

No-till Production.--As stated earlier, use of the no-till method of crop production reduces runoff, soil erosion, and the associated loss of nitrogen. Obviously the use of this tillage method, or similar conservation tillage methods, is going to reduce surface movement of nitrogen into surface waters. We do not have definitive information on whether or not leaching losses are increased and therefore offsets, to some extent, surface runoff reductions.

### Phosphorus

Following application, all phosphorus fertilizers react with the soil. The phosphorus then stays in that portion of the soil to which it has been applied. Because this reaction occurs, there is, for all intents and purposes, no phosphorus lost through leaching. There is concern about time and method of application. This concern is directed toward reducing the effect of soil reactions on availability to the crop rather than reducing losses through leaching.

Control of Runoff and Sediment Losses.--Because phosphorus is readily absorbed by soil constituents, any conservation practice that reduces soil erosion will reduce phosphorus movement into surface waters. This is particularly true for conventional tillage. In contrast to conventional tillage, continuous no-till production of crops presents one concern: Continuous application of phosphorus fertilizer to the soil results in a build-up of phosphorus availability in the soil surface. This increases the phosphorus concentration in water in contact with the soil's surface. Therefore, water moving across the surface of a field in which a crop is being produced by the no-till method may also convey a higher concentration of phosphorus. This could offset, to some extent, reduction of phosphorus losses due to reductions in soil erosion.

In summary, those conservation practices that reduce soil erosion losses and sediment movement into surface water are going to reduce the total movement of phosphorus conveyed into surface waters.

Rates of Application.--The previous comments on phosphorus imply that continued application after availability in the soil has been built to the point where the phosphorus available is sufficient to meet the needs of crops is not going to increase crop yields and is very likely going to increase phosphorus movement into surface waters. Therefore, in the interest of reducing production cost of the crop being produced and in the interest of all persons concerned with water quality, crop producers included, phosphorus application should not exceed recommended amounts determined by soil tests, so that movement of phosphorus into surface water may be reduced.



THE ROLE OF FERTILIZER AND AGRI-CHEMICAL  
BEST MANAGEMENT PRACTICES (BMPs)  
IN REDUCING BAY POLLUTION: HERBICIDES

By D. Raymond Forney and Chester L. Foy\*

The contamination of our environment by pesticides is a problem that has long received widespread attention. The first evidence that surface waters were contaminated appeared in the literature around 1945, about the time that modern chemical pesticides were first being manufactured (13\*\*). Public hysteria was kindled by the prophecy of doom inferred from Rachel Carson's Silent Spring (4), and attitudes toward agricultural chemicals were soon similar to those toward communists during the McCarthy era (8).

Herbicides, which are pesticides that exhibit toxicity against plants, have shared the notoriety of chlorinated hydrocarbon insecticides, such as DDT, as being responsible for a variety of environmental problems. In fact, herbicides as a class are far less hazardous to the environment than insecticides; the newer pesticides in general are much safer than the older ones (32, 33). In his book Are Pesticides Really Necessary? (3), Keith Barrons discusses many of the issues of interest when considering the social benefits of crop protection chemicals.

Beginning in about 1970, the submerged vegetation of the Chesapeake Bay disappeared from most of the extensive area that it formerly occupied (23, 24). The loss of these plants has been associated with a drastic overall decline in the bay's productivity (9). Because of the ecological importance of submerged vegetation to the estuary, its decline soon became the focus of extensive research.

Contamination of the bay by herbicides running-off agricultural land was suspected as a cause of the die-off of the submerged plants (6, 10, 23, 24). There was considerable circumstantial evidence to support this hypothesis:

- 1) Herbicide use on farmland in the bay's watershed had begun fairly recently, and this use had increased dramatically until the time when the submerged vegetation started to disappear (6, 10, 14, 18, 23).
- 2) Sophisticated analytical technology was available to demonstrate the presence of herbicide residues in streams draining agricultural fields and in the bay water (6, 10, 13, 23).

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\*\*Underscored numbers in parentheses refer to literature cited as references.

- 3) The herbicides most widely used in the bay's watershed were known to be toxic to most of the species of submerged plants that were disappearing from the bay (6, 10, 23).

In addition to these bits of circumstantial information, early opinions were strongly influenced by the emotional argument that is often associated with environmental issues involving any pesticide.

By the mid- to late-1970s, extensive research initiated with the support of both the Environmental Protection Agency (EPA) and private business was directed to investigating the amounts of herbicides present in the bay and the concentrations necessary to harm submerged vegetation. This work primarily focused on the herbicide atrazine, widely used in corn production throughout the world, and clearly the most used herbicide in the watershed of Chesapeake Bay (6, 10, 23). When runoff of soil and water occurs following rainfall on fields that have been treated with atrazine, a small amount of the herbicide moves through streams and eventually reaches the bay (31). Research has demonstrated conclusively, however, that the amounts of the herbicide that reach the sites where submerged plants grow are insufficient to harm such plants (9, 11, 18). Thus, most scientists (and the EPA) have dismissed the notion that herbicide runoff from farmland in the watershed of the Chesapeake Bay was involved in the decline of the bay's submerged aquatic vegetation (SAV) (9).

Currently, it is widely believed that the SAV has suffered from a reduction in the amount of light penetrating the water (9). The reduction of light penetration is attributed to turbidity caused by suspended sediments and an increased growth of algae (micro- and macro-scopic plants that live both free-floating and attached to the surfaces of submerged vegetation). This increased algal growth is known to have been stimulated by enrichment of the bay's water with nutrients such as phosphorus and nitrogen from a variety of sources. Thus, most of the current recommendations for improving the water quality and biological productivity of the Chesapeake Bay are aimed toward reducing the amounts of sediment and nutrients reaching the bay (7, 19, 20, 26, 27, 28, 29, 30).

Some scientists still express concern over potentially harmful effects of herbicides in the estuary (5). Therefore, it seems only prudent, if only as a matter of principle, that effort should be made to minimize the input of these materials to the bay. Fortunately, and as a consequence of the relationships among soils, water, fertilizers, and herbicides, the best management practices (BMPs) aimed at reducing soil erosion and the loss of fertilizers from agricultural land are also extremely effective at reducing herbicide losses (12, 25). In the remainder of this paper, we discuss the current status of herbicide uses in agriculture and the advances in weed control technology that have enabled the successful development of feasible BMPs for reducing bay pollution.

### The Role of Herbicides in Modern Society

Weeds are undesired plants, plants that are objectionable and that interfere with man's activities or welfare (34). They interfere with crop production by competing with crop plants for water, nutrients, light, air, and space; by blocking irrigation systems; by impeding planting and harvesting; by harboring other pests, such as disease organisms, insects, and rodents; and by reducing the quality of

produce. Weeds interfere with water utilization for transportation, recreation, and power generation. Weeds are unsightly, and they interfere with our aesthetic enjoyment of the landscape. Controlling weed growth is a major endeavor of farmers, highway departments, railroads, utilities, other industries, homeowners, and gardeners all over the world. They are by far the costliest of all pests, and the combined annual costs and losses due to weeds were estimated in 1982 to exceed \$18 billion (21). Farmers spend an estimated \$6.2 billion annually to control weeds, and, of this amount, \$3.6 billion is spent on herbicides.

Herbicides are chemicals used to "control, suppress, or kill plants, or to severely interrupt their normal growth processes" (34). There are currently more than 180 compounds and over 6,000 formulated products registered with the EPA for weed control (21). In addition, the discovery and development of new and better herbicides is the goal of extensive ongoing research institutions around the world. Investment by industry in agrichemicals research is estimated to exceed \$600 million annually (15).

Integrated pest management (IPM) is a concept that involves the use of intelligent, educated approaches to pest control, including the use of the most efficient combinations of cultural, mechanical, biological, and chemical methods (26). Most scientists believe that the development of IPM systems will aid in the improvement of agricultural productivity, and some feel that it will reduce threats to the environment from excessive pesticide applications. While advances in our understanding of weed biology, ecology, and susceptibility to various kinds of control technology proceed, herbicides will continue being the primary force in weed control and an essential factor in successful IPM systems (17, 21).

There are several reasons for the necessity of herbicides in modern cropping systems:

- 1) Weeds are ubiquitous and control measures are required in virtually all situations in all years.
- 2) A variety of herbicides are available, and most weeds can be controlled at practical costs.
- 3) Herbicides are fast-acting and effective against dense populations of weeds.
- 4) The equipment necessary for reliable, convenient herbicide application is already available and undergoing continued improvement (21).

In addition, chemical weed control has been the key factor in the successful development of reduced tillage practices (22), of which various permutations are involved in soil conservation and improved surface-water quality BMPs.

#### The Role of Herbicides in Agricultural BMPs

Because of the immense magnitude of water quality degradation that is now recognized as being the result of nonpoint sources of pollutants, various federal and state agencies have worked together to develop recommendations for improving the quality of surface water emanating from various types of land-use practices (7,

✓ 19). Because research on the problems regarding the decline of Chesapeake Bay productivity implicates sediments and nutrients as the most important pollutants originating on farm land, BMPs for agricultural land uses are aimed primarily at reducing the runoff of soil and fertilizer from our fields (20, 26, 27, 28, 29, 30). Thus, agricultural BMPs are very closely related to the types of practices that have long been advocated by soil conservationists and agronomists for maintaining or improving land quality and optimizing crop production. Now, however, because of the development of improved chemical weed control, reduced tillage can be recommended for most cropping systems in Virginia. Such tillage generally reduces the loss of soil and fertilizer from cropped fields.

Reduced tillage, minimum tillage, no-till, and conservation tillage are all synonyms for cropping practices in which the soil is less-often mechanically disturbed and some mulch is left on the surface to reduce the erodability of the soil (22). Through thousands of years, agricultural tillage, or cultivation, was the primary means by which weeds could be removed from among the crop plants. Prior to planting, fields were plowed, disked, and harrowed to destroy existing vegetation and prepare a clean seedbed. In the early stages of crop growth, multiple cultivations were carried out between the rows to prevent weeds. Each time the soil surface is laid bare, it is especially vulnerable to erosion. When rain falls, water begins to flow across the field, carrying with it loose soil particles and dissolved nutrients. Thus, valuable topsoil is lost, and expensive fertilizer is wasted. Simultaneously, nonpoint pollution is generated.

The best way to reduce soil surface erodability is to leave some mulch, principally vegetative residue, on the surface. Until recently, however, the lack of alternatives to cultivation for weed control made it impossible to successfully eliminate deep plowing and multiple cultivations. With the development of safe, effective herbicides to destroy existing vegetation at planting time and to provide residual weed control, successful reduced tillage practices become possible (22).

Two herbicides developed in the 1970s, paraquat and glyphosate (Roundup), made reduced tillage possible. Both chemicals are extremely effective when sprayed onto the foliage of existing plants (34). Paraquat, which predated glyphosate and provided the first real breakthrough for the no-till concept, is fast-acting and desiccates only the green tissues contacted by spray solution. Glyphosate is translocated in plants and kills slowly but more thoroughly; it is effective against perennial species. Both chemicals become tightly bound to soil particles on contact, and thus are unavailable to plants and made biologically inactive.

The control of weeds that germinate in cropped fields after planting relies heavily on soil-applied herbicides having residual activity. Many of the chemicals used in conventional tillage systems also can be employed in conjunction with conservation-tillage practices. Long-term weed control is especially important when cultivation is eliminated as an option, and considerable research has already been conducted to optimize the activity of soil-applied herbicides under the altered micro-environments found in reduced-tillage situations. Because the use of herbicides prior to the widespread adoption of conservation tillage practices was found not to be of significant concern as a source of bay pollution, we can be sure that their continued use under conditions that reduce the amount of runoff is of even less concern.

Several other new developments in herbicide technology have had a substantial impact on the adaptability of reduced-tillage systems. Among the most important for Virginia agriculture was the discovery of several compounds that have excellent activity against grasses and absolute selectivity for broadleaf crops such as soybeans.\* Most of the row-crop land lying in Virginia's portion of the Chesapeake Bay watershed is cropped in rotations that include soybeans. Much of this land is infested with bermudagrass or johnsongrass, tough perennial weeds that reproduce in part through extensive underground rhizome systems. Prior to the availability of the new graminicides, control of these grasses in soybeans depended in part on deep plowing to weaken the rhizomes and make them more susceptible to soil-applied herbicides. Thus, reduced-tillage systems could not be recommended for soybeans on much of Virginia's farmland. Now, no-till soybeans can be successfully grown even where heavy infestations of perennial grasses exist.

Among the exciting recent advances in weed control technology has been the discovery of some remarkable new classes of chemicals with herbicidal activity at extremely low dosages. These compounds are active against weeds after soil applications at rates in the range of grams per hectare (1, 16), and among them are herbicides with excellent selectivity for major crops such as small grains and soybeans. The future development of these products will no doubt enhance the successful widespread adoption of conservation tillage practices.

Recognizing public concern over the persistence of pesticide residues in the environment, the herbicide industry is searching for new chemicals that are totally biodegradable and yet still effective against weeds. One such product currently in the developmental stage for control of annual grasses and broadleaf weeds in soybeans is a chemical that contains only carbon, hydrogen, and oxygen. In the soil, the compound is completely broken down to carbon dioxide and water within a matter of weeks (2).

### Conclusions

Herbicide runoff from agricultural land was once suspected as a leading cause of the decline of Chesapeake Bay submerged aquatic vegetation and the associated deterioration of the bay's water quality and productivity. Research proved that the amounts of herbicide reaching the bay were not sufficient to harm the aquatic vegetation, however; and soon the input of sediment and nutrients was implicated as the major factor. Agricultural BMPs designed to reduce soil erosion and fertilizer runoff have been developed and are being recommended and encouraged throughout the watershed. A major aspect of BMP programs involves the reduction of tillage practices associated with crop production. The success of this aspect depends on herbicides to replace mechanical means of weed control. New herbicide technology has made reduced-tillage farming a very practical reality. Thus, herbicides have a very important role in our current and future efforts to reduce Chesapeake Bay pollution.

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## MANAGING FERTILIZER AND AGRI-CHEMICAL USE WITHIN THE BAY WATERSHED: FUNGICIDES, NEMATICIDES, AND INSECTICIDES

By Patrick M. Phipps\*

About 650 agrichemical companies produce 90 percent of the crop protection materials in the world, but only 40 conduct research for the development of new pesticides. After discovery of a new pesticide, it may take five to ten years to develop the necessary data on efficacy, residue, and toxicology to register a compound for commercial sale. The cost of these efforts often range from \$6 million to \$15 million per compound. An additional investment of \$5 million to \$50 million often is required for a full-scale manufacturing plant. A thorough study of all chemicals or pest control agents is required to identify and avoid real health or environmental hazards. When the inventor is satisfied with the performance and safety of a new product, an application for registration is submitted to the Environmental Protection Agency (EPA) for its review. This application includes detailed data on biological efficacy, chemical properties, toxicity, amount and nature of residues, metabolism, and possible impact on the environment.

Registration of a chemical with EPA authorizes its use for specific purposes that are described on a label attached to each package when offered for sale. In the United States, it is illegal to use a registered agricultural chemical in a manner that is not consistent with the instructions on the label. As users of restricted-use pesticides, commercial producers of crops are required to be certified applicators. These certificates must be updated annually and require attendance at short courses that focus on measures for safe handling and disposal of pesticides and their containers. In Virginia, the Virginia Department of Agriculture and Consumer Services and the Virginia Cooperative Extension Service administer the certification of pesticide applicators.

Regulations that govern the use of pesticides are aimed at protection of humans and the environment. Some useful cultural strategies for pest control, such as burning, soil pH adjustment, and moldboard plowing, may be regulated in future years. Society regulates pesticides to protect humans and the environment, and these regulations are justifiably stricter now than in previous decades. As human populations increase, even less tolerance can be expected for environmental or human hazards associated with specific pest control technologies.

In almost all cases, chemicals are used on a preventative basis for pest control because early-warning systems for detection of disease and/or the presence of damaging pest populations and environmental conditions conducive to disease

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development are absent. The dependency on chemicals for pest control has been perpetuated by the absence of effective alternative measures; such as disease resistant varieties of plants and disease-suppressive cultural practices. Although numerous chemicals are registered for use on field crops, the need to continuously research and refine strategies for chemical control of pests is sustained by changes in production technology, dynamic shifts in pest populations, and discoveries on the biology of pests. Research to develop improved chemicals has resulted in the recent development and sale of less toxic materials that effectively control pests at dosages of a few ounces per acre rather than the previous tens-of-pounds per acre. An attractive attribute of these compounds has been their selective action only on target pests coupled with nonpersistence in the environment.

The social taboo against filthy, putrid, and/or decaying food has contributed to the overuse of pesticides. Many can remember the pest free and lush growth of potatoes that were sprayed with DDT for insects and zineb for blight. Others may recall the near total control of nematodes in soil with EDB or possibly DBCP. Materials such as DDT and EDB provided near absolute control, but the risk to man and the environment has proven too great to justify their continued use in pest control. Emphasis in pest control today focuses more on the design of strategies that enable man to live with pests, rather than attempts in eradication of pests; historically, these attempts have often proven to be unsuccessful. Today, disease and/or pest management is advocated by most pest control experts. The term "management" conveys the concept of a continuous process rather than an event accomplished with application of an extrinsic factor. Management implies that diseases and pests are inherent components of the agroecosystem, and that they must be dealt with on a continuous, knowledgeable basis. Such management strives in principle to maintain damage or loss below an economic injury level or at least minimize occurrences above the level. The ultimate objective in disease and/or pest management is the development of predictive models through which management decisions can optimize benefits to the producer, consumer, and the public-at-large.

Modern strategies for disease and pest management are based strongly on the use of chemicals, selected cultural practices, and host-plant resistance. Man's input into crop production is not to maintain a biological balance in the agroecosystem (in pure ecological terms), but to maintain the dynamic state of imbalance that maximizes production of his crops. As discussed previously, safeguards must be present in any management strategy to minimize and/or prevent the occurrence of risk for damage to man and his surrounding environment as a result of these ecological imbalances.

### The Virginia Situation

✓ Fifteen field crops are produced regularly on about three-million acres of crop land in Virginia. Major crops cultivated in regions of Virginia within 100 miles of Chesapeake Bay include soybeans, corn, wheat, peanuts, tobacco, and vegetables. Disease and pest management programs are currently used routinely by most producers of these crops as a result of efforts by the Virginia Cooperative Extension Service. Such programs and services include: diagnostic and troubleshooting services, training programs for disease and insect scouts, numerous tours and educational meetings for producers, the predictive nematode assay program, and the peanut leafspot advisory program. All of these programs focus on the concept of disease and pest management. Producers are informed and updated

continuously on management strategies to achieve effective, economical protection against losses from diseases and pests. An extensive discussion would be necessary to explain these programs and their benefits to producers, consumers, and the public-at-large. Rather than pursue such a discussion, which would necessitate brevity, I have chosen to discuss details of two recently developed programs that demonstrate our commitment to the development of strategies for disease management and the judicious use of agricultural chemicals.

The Predictive Nematode Assay Program--Since the first recognition of nematode damage in field crops and the advent of chemicals called nematicides growers have used these chemicals to prevent nematode damage. In the light sandy textured soils of southeastern Virginia, plant parasitic nematodes have been a major limiting factor in crop production. In 1978, a pilot program to determine the feasibility of a prescription approach to nematode control in field crops was initiated in southeastern Virginia. Growers participated in this program by collecting soil samples from fields after the fall harvest of crops. The soil samples were received by the Virginia Cooperative Extension Service, and the numbers and kinds of plant parasitic nematodes in each sample determined by laboratory analyses. By mid-February 1979, growers were provided a report on these results and a recommendation for management based on the crop to be grown. A surprising result of these tests was that, of more than 250 samples submitted from fields to be planted to peanuts, only 49 percent contained populations of nematodes that would pose a potential threat to peanut production. In 1979, the program was expanded; and of more than 400 samples tested, about 54 percent contained potentially damaging populations of nematodes. These results clearly indicated that the routine use of nematicides on the 96,000 or more acres of peanuts planted annually in Virginia was unwarranted. Subsequent field research trials verified that little or no economic benefits resulted when nematicides were used in fields where nematode species damaging to peanuts were absent or present in numbers below threshold levels for economic loss of yield.

As a result of support from the agricultural chemical industry, commodity groups, and the Virginia Agricultural Foundation, the program was expanded in 1980 to accommodate a large number of samples from growers of all field crops, nursery crops, and fruits. In the case of peanuts, growers would spend an estimated \$20 per acre for nematode control, or about \$2 million annually in Virginia if this program were not available. Based on current estimates of the predictive nematode assay program, the use of nematicides is justified only on about 60 percent of Virginia's 1984 peanut acreage. The utilization of this program can save an estimated \$800,000 in production costs in 1984. With respect to soybeans and corn, the predictive nematode assay had made nematode control a decision based on fact rather than mystery. About 15 percent of the corn acreage in southeastern Virginia would benefit from nematicide treatment based on recent results of nematode assays. Although up to 50 percent of the soybean acreage in the same area shows a need for nematode control, growers now have the option to use nematicides or in certain instances resistant varieties as well as cultural practices. Several cyst nematode resistant varieties of soybean are now recommended to growers. An additional option to growers with nematode problems is to double-crop soybeans and wheat. This management strategy affords producers of soybeans with a minimum of risk for nematode damage without a need for a nematicide treatment. Tobacco producers have also found the predictive nematode assay useful in efficient crop management and control of the very devastating tobacco-cyst nematode.

The Virginia Peanut Leafspot Advisory Program--Early and late leafspot of peanuts are caused by two fungi (Cercospora arachidicola and Cercosporidium personatum) that are of major economic significance in all peanut-producing areas of the world. Both diseases may cause yield losses of less than one percent or more than 50 percent, depending on disease pressure and management. Fungicides are used extensively in foliar sprays for leafspot control, because of inadequate disease resistance in commercially acceptable peanut varieties. Following the advent of organic fungicides for leafspot control in the early 1970s, growers in the United States routinely applied these fungicides at 10- to 14-day intervals beginning as early as 30 to 40 days after planting and continuing until 14 to 21 days prior to harvest. Six or more fungicide applications have been a common practice in a growing season, when a 14-day spray program is followed. At today's cost, a grower spends about \$10 just to spray an acre of peanuts one time. The total cost for spraying Virginia's annual peanut acreage of nearly 100,000 acres amounts to \$1 million per fungicide application, or \$6 million to \$7 million if a 14-day spray program were used over an entire growing season. Such intense management is currently practiced in peanut-producing states such as Georgia and Florida.

Virginia is currently the only state where an operational peanut leafspot advisory program exists. North Carolina and other states are currently developing and/or conducting feasibility studies on the utility of a similar program in their region. The Virginia peanut leafspot advisory program has become a classic example of "on-line" use of high technology for control of a plant disease. The success of this program in Virginia was a result of cooperative research by Virginia Tech, the National Aeronautics and Space Administration (Wallops Island), and the United States Department of Agriculture (USDA). The first objective in this research was realized in 1979 with implementation of an agro-environmental monitoring system (AEMS). As a computerized system with automated electronic sensors and micro-processors for data collection at two locations in Virginia's peanut production area, this system has provided an accurate record of weather conditions at 10-minute intervals during each day. A central data collection center maintained by the USDA at the Tidewater Research Center in Suffolk automatically retrieves data from each of the field monitors and assimilates these data into useful information such as the Virginia peanut leafspot advisory. The data also are used in current research programs to develop predictive models to forecast outbreaks of other diseases and also insects, to project needs for crop irrigation, and to develop predictive models for crop growth.

Records of ambient temperature and relative humidity are required to estimate daily infection rates for leafspot in peanuts. Advisories as to weather conditions being favorable or unfavorable for infection and spread by the fungi that cause leafspot are printed automatically each day by the central computer at the Tidewater Research Center. In 1984, weather monitoring stations at Wakefield, Capron, and Suffolk will afford issuance of separate advisories to serve the major sections in Virginia's peanut production area. Almost 85 percent of all peanut fields within the state will be within a 15-mile radius of at least one of these monitors.

Leafspot advisories have been issued daily in Virginia by the Virginia Cooperative Extension Service from June 10 until September 25 since 1981. Test demonstrations to verify the utility of the advisories demonstrated effective leafspot control with only two fungicide applications in 1982, and three fungicide applications in 1981 and 1983. At a cost of \$9.50 per acre for a single application in 1983, the total benefit of the leafspot advisory was \$38 per acre or nearly \$3.6 million on the

96,000 acres grown; assuming three applicatons were made instead of seven on a 14-day schedule. Numerous growers have testified as to their success in utilization of advisories and expressed their support for continuation of the program. Growers obtain daily advisories by listening to one of several local radio as well as two television stations or by calling a toll-free telephone number. A code-a-phone answers growers calls and delivers daily advisories. This machine logged 1,343, 1,617, and 3,160 calls in 1981, 1982, and 1983, respectively. As a result of grower utilization and support, leafspot advisories for peanuts are expected to continue as an integral part of peanut disease control strategies in Virginia.

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## VIRGINIA AGRICULTURAL AND URBAN BEST MANAGEMENT PRACTICES PROGRAMS

By C. Scott Crafton\*

Studies of the Chesapeake Bay and Chowan River drainage basins of Virginia have concluded that both point and nonpoint sources of pollution are contributing to water quality degradation and subsequent declines in beneficial uses of those water bodies. In response to these findings, the Governor of Virginia proposed state initiatives to accelerate pollution control efforts in both drainage basins. The Commonwealth's Chesapeake Bay Initiatives, as amended by the 1984 Virginia General Assembly, include \$10.4 million for the Chesapeake Bay and \$125,000 for the Chowan River drainage basins during the 1984-86 biennium. The U.S. Environmental Protection Agency (EPA) has also indicated its intention to contribute federal funds to the Chesapeake Bay clean-up effort by the Commonwealth.

The Virginia Soil and Water Conservation Commission (SWCC) was assigned primary responsibility for developing a program to deal with agricultural nonpoint source pollution problems. To assist in this effort, the commission assembled a committee representing agricultural, soil conservation, and water quality interests and expertise in Virginia. The task of the committee was to develop a plan for a comprehensive agricultural pollution abatement program in the Chesapeake Bay and Chowan River basins of Virginia.

The plan was developed on the basis of state funding of \$2.5 million for the Chesapeake Bay and \$125,000 for the Chowan River basin during the 1984-86 biennium. An additional \$500,000 for the state's Chesapeake Bay Program was contributed by the EPA, making funds available for bay-oriented efforts total \$3.0 million. The plan was designed with this primary objective: Develop a program that, with limited available resources, would have the greatest potential for maximizing water quality improvement in the short term. At the same time, the importance of developing long-range plans and programs was recognized. There was a clear consensus that any meaningful program to improve water quality in the Chesapeake Bay and Chowan River drainage basins would require a substantial and sustained long-term commitment by state, federal, and local units of government.

### Soil Conservation and Water Quality

The objective of the agricultural nonpoint source pollution control program is to get farmers to implement best management practices (BMPs) to reduce pollutant contributions from individual farms. This goal is generally compatible with the goal

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of national soil and water conservation programs that have been operating in Virginia for the past 50 years through an established administrative and technical framework designed to serve farmers' conservation needs. Farmers generally understand and accept this system although not all of them take advantage of it.

While compatible with state water quality goals, the goal of the current national conservation program is not identical. The current national priority is to control erosion. Conserving soil generally benefits water quality, but the national program emphasis is with on-farm benefits, i.e., reducing soil loss to maintain agricultural productivity. The state program's water quality goal is concerned more with off-site benefits and has a broader focus than just soil erosion and sediment control.

To be successful, the agricultural nonpoint source pollution control program must direct, to the extent possible, some existing soil conservation program resources toward water quality improvement and supplement those resources with the additional state resources aimed at water quality improvement objectives. The challenge is to merge these two compatible yet different programs into a single coordinated program that remains understood and accepted by the farming community.

Motivating farmers to implement BMPs is the key issue. The traditional voluntary approach has been to make technical and financial assistance available to those who request it. This has resulted in many excellent soil and water conserving practices being implemented by a number of enlightened farmers over the years. The farmers who use good conservation practices are rewarded by the long-term productivity benefits they receive. However, when emphasis is shifted to off-site benefits, water quality, this system fails since the farmers who create the greatest pollution problems are not necessarily the ones who request assistance. An effective agricultural nonpoint source pollution control program will require a strategy designed to obtain cooperation from the farmers who create the greatest pollution problems.

#### Pollutants and Sources

The EPA's Chesapeake Bay Study identified nitrogen and phosphorus as the primary pollutants contributing to water quality degradation in the bay. Similar studies in the Chowan River basin also indicate nutrient over-enrichment as a major problem. These nutrients cause production of excess algae, which, when they die and decay, utilize available oxygen. Algae also create turbidity problems. The decline in submerged aquatic vegetation and reduction in certain desirable fish species in the bay has been linked to this nutrient problem.

Sediment from soil erosion is a pollutant that causes significant impacts. The sediment delivered to the streams from disturbed land reduces stream depth; carrying capacity of shipping is reduced; and costly dredging operations are often required. Sediment is also a transporter of phosphorus and nitrogen and in this way contributes to the nutrient enrichment problem. Sediments also causes turbidity problems.

The EPA's Chesapeake Bay watershed computer model estimates that approximately 39 percent of the phosphorus and 67 percent of the nitrogen

delivered to the bay come from nonpoint sources during an average year of precipitation. Cropland has been identified as the principal nonpoint source nutrient contributor. Approximately 27 percent of the phosphorus and 60 percent of the nitrogen delivered to the bay are contributed by cropland.

Animal waste is also a significant contributor to the nutrient problem. Although the total of nutrients contributed from animal waste sources is not nearly as great as from cropland, the concentration per unit area of land can be significantly higher. A water quality monitoring project in the Chowan 208 Study showed that runoff from test watersheds containing multiple swine-feedlots contained substantially higher concentrations of nutrients than runoff from crop-farming- and wooded-test areas. The cost of constructing animal waste management systems is considerably higher than typical cropland practices. Consequently, these added costs have to be taken into account in developing a nutrient management strategy.

### Development of the Virginia Strategy

The initial program development strategy was to focus efforts on small watersheds, a strategy used by other states. However, the lack of a reliable data base precluded this option. As a first step, the agricultural characteristics of the entire basin were analyzed to select priority sub-basins rather than watersheds so that the initial effort could be effectively targeted. The priority sub-basins selected are the Rappahannock River, the York River, the Eastern Shore, and the Shenandoah River--a major tributary of the Potomac. These sub-basins were selected because they are dominated principally by agricultural nonpoint sources of pollution and have reasonably good water quality. An effective BMP program can help to ensure that these sub-basins do not deteriorate further. In addition, a small demonstration watershed will be selected for intensive activities to evaluate small-scale water pollution control accomplishments.

### Program Components and Geographic Areas

Table 1 depicts the relationship of the six SWCC program elements to the three geographic areas (basinwide, sub-basins, and small watershed) covered by the program. The basin-wide classification includes the 68 counties in the Chesapeake Bay and Chowan River drainage basins (figure 1). The priority sub-basins classification includes counties in the Rappahannock River, York River, and Shenandoah River basins plus the two Eastern Shore counties. The small watershed will be selected from within the priority sub-basins. Program activities and dollar resources are more intensively allocated to the small watershed and priority sub-basins than they are to the basin-wide area.

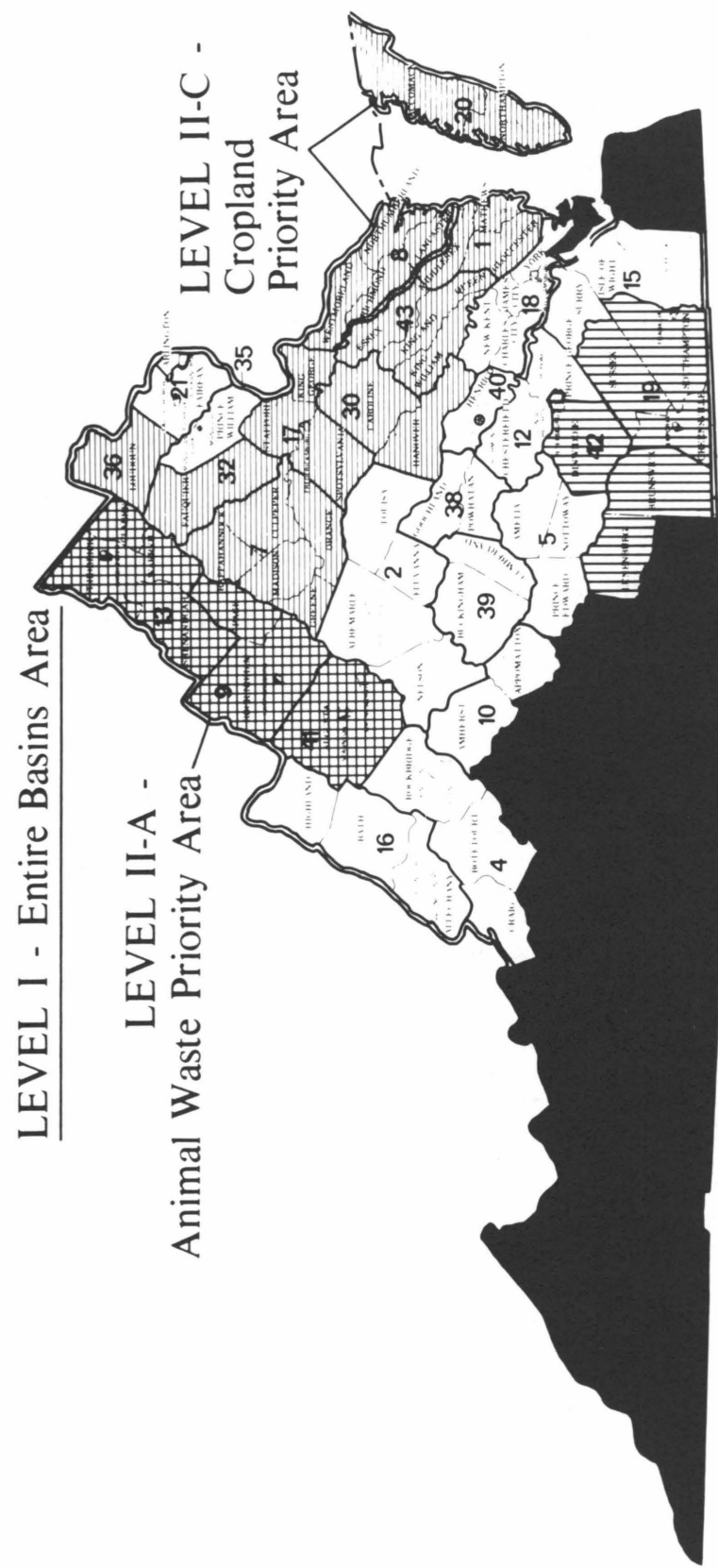
Because of their high water-quality benefits almost two-thirds of the \$2.5 million state monies available for the program will be spent for BMP cost-sharing activities in the three geographic areas. However, animal waste systems and grazing land protection BMPs will be cost shared only in the Shenandoah River sub-basin. Basin-wide BMPs include no-till into cover crop, grassed filter strips, critical area stabilization, and reforestation of erodible cropland. Other BMPs will be cost shared only in the priority sub-basins. These BMPs include strip cropping, terrace systems, diversions, contour farming, sod waterways, and water and erosion control structures.

Table 1  
Virginia - Chesapeake Bay Agricultural BMP Program

PROGRAM ELEMENTS	BASIN-WIDE	PRIORITY SUB-BASINS (Rappahannock, York Eastern Shore, Shenandoah)	SMALL WATERSHED
<u>BMP COST-SHARING</u>	<ul style="list-style-type: none"> <li>No-till into Cover Crop (\$6/acre)</li> <li>Grassed Filter Strips (\$5.10/linear foot)</li> <li>Critical Area Stabilization (25% of ACP Cost)</li> <li>Reforestation of Erodeable Cropland (\$50-75/acre)</li> </ul>	<p><u>SUPPLEMENTAL ACP COST SHARING</u></p> <ul style="list-style-type: none"> <li>Strip Cropping Systems</li> <li>Terrace Systems</li> <li>Diversions</li> <li>Contour Farming</li> <li>Water &amp; Erosion Control Structures</li> <li>Sod Waterways</li> <li>Animal Waste Systems*</li> <li>Grazing Land Protection*</li> <li>*BMP's Cost Shared in Shenandoah Priority Sub-basin only.</li> </ul>	
<u>EDUCATION</u>	<ul style="list-style-type: none"> <li>Full Time Coordinator</li> <li>Targeted at Non-participating Farmers (i.e., rental farmers)</li> <li>Direct Farmer Contact</li> <li>Nutrient Management Mailings</li> <li>Farmer Recognition Program</li> </ul>	<ul style="list-style-type: none"> <li>Special Project Grants to Conservation Districts</li> </ul>	<ul style="list-style-type: none"> <li>Intensive Education Program in Demonstration Watershed</li> <li>1 of 7 FTE</li> </ul>
<u>TECHNICAL ASSISTANCE</u>	<ul style="list-style-type: none"> <li>Additional Conservation District Employees (7 FTE)</li> <li>State Agricultural BMP Specialist (1 FTE)</li> <li>IPA Employee With SCS (1 FTE)</li> </ul>	<ul style="list-style-type: none"> <li>50% of time</li> <li>50% of time</li> <li>50% of time</li> </ul>	<ul style="list-style-type: none"> <li>25% of time</li> <li>25% of time</li> <li>25% of time</li> </ul>
<u>BMP DEMONSTRATION AND EVALUATION</u>	<ul style="list-style-type: none"> <li>Innovative BMP Demonstration Grants to Districts (i.e., Nitri-fication Inhibitors, Aerial Seeding of Cover Crops, etc.)</li> <li>Rainfall Simulation Demonstrations on Farms with BMPs (6 demonstrations)</li> </ul>	<ul style="list-style-type: none"> <li>50% of effort</li> <li>3 of 6 demonstrations</li> </ul>	<ul style="list-style-type: none"> <li>25% of effort</li> <li>1 of 6 demonstrations</li> </ul>
<u>DISTRICT RESOURCE TARGETING</u>	<ul style="list-style-type: none"> <li>Districts set Priorities for Technical and Financial Assistance Based upon Available Data (from SCS &amp; ASCS)</li> </ul>	<ul style="list-style-type: none"> <li>Target Farm data base developed from aerial photography, soil surveys and USGS topographic information to help districts set priorities (Rappahannock/York Sub-basins)</li> </ul>	<ul style="list-style-type: none"> <li>Target Farm data base will be augmented with field surveys in demonstration watershed</li> </ul>
<u>EFFECTIVENESS MONITORING</u>	<ul style="list-style-type: none"> <li>SCS Progress Reporting System</li> <li>Agricultural Conservation Trend Analyses (Annual Statistical Survey)</li> </ul>	<ul style="list-style-type: none"> <li>Watershed modeling using target farm data base. (To estimate pollutant load reductions.)</li> </ul>	<ul style="list-style-type: none"> <li>Water quality monitoring in the demonstration watershed</li> </ul>

# Chesapeake Bay-Chowan River Non-Point Programs

Figure 1



Soil and Water Conservation Districts Within Program Boundaries

<b>Animal Waste Priority Area</b>	<b>Cropland Priority Area</b>	<b>Other SWCDs Also Within Program Area</b>
Headwaters (41)	Culpeper (7)	Colonial (18)
Lord Fairfax (13)	Eastern Shore (20)	Piedmont (5)
Shenandoah Valley (9)	Hanover-Caroline (30)	Henricopolis (40)
	John Marshall (32)	James River (12)
	Loudoun (36)	Robert F. Lee (10)
	Northern Neck (8)	Thomas Jefferson (2)
	Three Rivers (43)	
	Tidewater (1)	
	Tri-County (17)	
<b>Chowan River Basin Program Area</b>		
Appomattox River (42)		
J. R. Horsley (19)		
Southside (3)		

Educating and mobilizing the farmer is an essential program element. The Virginia Cooperative Extension Service will become the vehicle for disseminating most of the information through a full-time educational coordinator who will work directly with extension agents in the 68 counties that lie totally or partially in the Chesapeake Bay and Chowan River basins. The education element will include a nutrient management advisory effort. Funds will be made available to Soil and Water Conservation Districts so they can employ technicians to aid the farmer in designing and installing BMPs.

Several innovative best management practices demonstrations, such as the use of nitrification inhibitors, aerial seeding of cover crops, and rainfall simulation exercises, are planned. A fairly recent development in the agricultural chemical industry is a product known as a nitrification inhibitor. This chemical kills bacteria that cause nitrogen to remain in the surface layer in a form unavailable to the plants. But this chemical has not been widely tested in Virginia; the cost of applying this chemical is currently about \$6 per acre. In the normal season corn and soybeans are often harvested too late in the fall to get a cover crop established. Aerial seeding provides a means of getting the cover crop started to protect the cropland over the fall and winter before harvesting the soybeans or corn. A large-scale, mobile rainfall simulator, covering 1.4 acres, will be used on various sites to create synthetic, runoff-producing rainfall events. Treated and untreated areas can be observed and evaluated for sediment and nutrient content to determine BMP effectiveness.

Important demonstration work can be accomplished by eventually targeting smaller watersheds as priority areas rather than the larger sub-basins now used. To select the priority areas, a data base showing the areas of greatest potential pollution is needed. That data base does not exist at present but two approaches are available: (1) a labor intensive, farm-by-farm inventory and assessment, or (2) the development of what is called an unobtrusive measure of pollution potential. By using one of these approaches a data base will be completed by the end of 1984. At that point, small watershed strategies will be developed. Using a combination of high altitude photography, county soil maps, and U.S. Geologic Survey topographic maps, special maps that will rank the farm units in each county according to their pollution potential will be developed. This type of data, which has been used in a similar form for watershed planning in other areas of the country, will provide a target-farm data base; it will be available in its completed form within six months. This approach is very important for five basic reasons:

- 1) It "puts the points" into nonpoint source pollution.
- 2) It provides specialized maps for watershed planning.
- 3) It saves countless field investigation hours.
- 4) It enables the SWCC to focus resources where they will be most effective.
- 5) It provides the needed tool to develop an aggressive farmer participation effort.

The final element of the SWCC program is effectiveness monitoring. Watershed modeling using the target-farm data base will provide estimates of pollution load

reductions. Also, water quality monitoring activities will provide measures of effectiveness in the demonstration watershed.

### Program Delivery

In Virginia, a very close working relationship exists between the state, the U. S. Department of Agriculture, the soil and water conservation districts, and the Cooperative Extension Service. This institutional arrangement has existed for many years, and its established administrative and technical structure is generally understood and accepted by the farming community. Many may question the decision to use those who have traditionally focused on conservation and erosion to carry out what is essentially a water quality program. But early-on a strong commitment was received from both the U.S. Soil Conservation Service and the Agricultural Stabilization and Conservation Service to adjust some of their priorities to focus on water quality goals. Last year, for the first time, Virginia had an opportunity to test the combined capability to implement a state agricultural BMP program using this existing structure. That program was called the PIKY Back program because it was tied to the federal PIK (payment-in-kind) program. Virginia provided state cost-share assistance to farmers who agreed to designate a portion of their PIK acreage to grassed filter strips along streams. The result of this one-year program, with a three-year commitment by cooperating farmers, has been the establishment of over 150 miles of filter strips in the Chesapeake Bay and Chowan River basins. This unique program received a national commendation from the Soil Conservation Society of America. This cooperative effort on a test basis demonstrated that a structure existed upon which to build a broader BMP program.

### Urban Program

Virginia's urban nonpoint source initiative will focus on erosion and sediment control and stormwater management from construction activities. Even though there has been a state urban BMP program since 1974, many local governments, the level of government with administrative responsibilities for the program, unfortunately assign a low priority to erosion control and stormwater management.

Funds will be used to share the cost of ten urban conservation specialists to augment the implementation of local programs by providing professional or technical personnel to assist local officials and developers; and, to conduct training and public awareness programs promoting urban BMP implementation. These specialists will be targeted to the most rapidly urbanizing areas of the basin, basically the urban corridor from Washington through Richmond to Hampton Roads.

The other element is an urban BMP demonstration program. The first such project, already in the planning stage, is a large recreational park in the Occoquan watershed of Prince William County that will employ three different urban BMPs (porous pavement, infiltration trenches, and grassed waterways) to reduce pollutant loads from paved parking areas. Porous pavement is a layer of porous asphalt installed over a thick layer of stone allowing stormwater to return to the ground. An infiltration trench is a large trench that is excavated and filled with stone. Surface runoff is routed into the trench and is then returned to the ground. A grassed waterway is a wide shallow channel that is constructed in the earth and is seeded to create a good stand of grass. Surface runoff is filtered by the grassed-lined channel similar to the filter-strip practice in agricultural BMPs.

Each of these BMPs will be intensively monitored for water quality improvement to determine their effectiveness. This project will become the site of local and statewide educational seminars on urban stormwater management. Two or three similar demonstrations are planned in other urbanizing watersheds.

#### Effectiveness Monitoring

Four methods will be used for monitoring overall program effectiveness: (1) A computerized progress reporting system will be used to provide a generalized calculation of sediment and phosphorus load reductions resulting from BMP implementation. (2) A BMP trend analysis will be conducted through establishment of a representative and statistically valid sample of farms within the Chesapeake Bay basin. (3) A watershed model using the priority sub-basins data base will predict results from BMP installation. (4) In the small demonstration watersheds and on the sites of urban BMP demonstrations, water quality monitoring will be used to measure water quality benefits from an intensive BMP program.

LEGISLATION: WHAT IS? WHAT OUGHT TO BE?  
THE ROLE OF STATE LAW IN IMPROVING LAND-USE MANAGEMENT  
WITHIN THE VIRGINIA PORTION OF THE CHESAPEAKE BAY WATERSHED

By William E. Cox\*

The importance of land-use controls as a water quality management device for the Chesapeake Bay has become increasingly recognized in recent years. The existence of a relationship between the quality of a body of water and land use within its drainage area has long been recognized, but an accurate understanding of this relationship is still evolving. Complex interactions within individual natural systems obscure cause-and-effect relationships, and variations among different systems hinder the formation of general rules. In the case of Chesapeake Bay, the scope and complexity of the system are formidable obstacles to understanding; even the magnitude of the water quality problem has only recently been brought into focus. Nevertheless, a consensus has developed that land-use controls must be a basic component of any effective water quality management strategy for the bay.

Increasing recognition of the role of land-use controls as a component of the water quality management program for the bay raises fundamental institutional issues. Primary concern focuses upon questions about intergovernmental relations. While water quality management programs generally have been viewed as the responsibility of state and federal governments, primary responsibility for land-use control traditionally has been delegated to local governments. Valid reasons continue to exist for local responsibility in this area of governmental activity. Many of the impacts of land-use decisions are primarily local in nature, and variation in local conditions indicates the importance of local input. But the existence of significant local authority in the area of land-use controls is a potential constraint on the development of comprehensive water quality management programs. The separation of authority to control point sources of pollution from the authority to control land-use activities that cause nonpoint pollution is a significant institutional factor in the effort to improve water quality in the bay.

Recognition of this institutional discontinuity and its impact on achievement of environmental objectives has resulted in a general trend toward greater involvement of state government in land-use control. At the extreme, this trend has involved adoption of direct state controls over a substantial range of land development activities. This approach is the exception, however, and lesser degrees of state involvement remain the norm. These approaches involve such measures as

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establishment of direct state controls over narrowly defined land-use activities, establishment of state guidelines for local land-use control programs, and establishment of varying degrees of direct state participation in local program administration.

Although land-use controls remain primarily a local responsibility in Virginia, several examples of increasing state involvement can be identified. Wetlands legislation has been passed providing for imposition of state guidelines and state review of local administration. An erosion and sediment control program has been established to be administered locally under state guidelines. Most recently, a hazardous waste facilities siting act has been adopted limiting local powers regarding siting decisions.

In terms of Chesapeake Bay water quality management, one of the potentially most significant developments has been establishment of best management practices (BMPs) for control of nonpoint sources of pollution. However, these BMPs have not been established as legally enforceable regulations on a statewide basis. To encourage voluntary compliance with certain nonpoint pollution control practices, the state has experimented with use of financial incentives in the form of cost sharing with landowners. This program is scheduled for expansion within the bay's drainage area. Therefore, the existing institutional structure in Virginia consists of a variety of interacting components involving state and local governments, with local government continuing to exercise primary authority for direct control of land use.

This paper presents an overview of institutional issues associated with use of land-use controls for the purpose of protecting water quality in Chesapeake Bay. The paper begins with an assessment of the scope of existing state legislation providing for establishment of land-use controls. Second, this authority is evaluated in terms of its potential for providing effective control of nonpoint sources of pollution affecting the bay, with special emphasis on restrictions affecting use of existing authority. The paper concludes by considering changes needed for mitigation of existing restrictions and improvement of water quality management capabilities.

### Virginia's Existing Land-use Legislation

Land-use legislation is not an exclusively defined category of law but consists of a variety of measures distributed within the Code of Virginia. If the term land-use legislation is viewed expansively, several statutory enactments can be included. For example, environmental legislation generally could be considered as land-use controls since certain land-use activities can be constrained or prohibited. Nonpoint pollution controls have the greatest potential to act as a generally applicable land-use control, and consideration of the state's water quality management program will be limited to this component. Since it has significant impact on the operation of other land-use controls, recent legislation for siting hazardous waste facilities will be briefly reviewed. Included also is authority for the state's soil and water conservation districts to adopt land-use controls. Traditional control measures administered by counties and municipalities to be included are the local comprehensive plan, zoning, and subdivision regulations; erosion and sediment control; and control of development affecting wetlands and

coastal primary sand dunes. In addition, powers of taxation and investment in public services will be examined since they also can directly influence land use.

The State Water Quality Management Program.--The state water quality management program has primarily been devoted to control of waste discharges from industries and municipal treatment plants, but state legislation does not restrict the program to these activities. The State Water Control Law provides authority for the State Water Control Board (SWCB) "[t]o exercise general supervision and control over the quality, management, and distribution of all State waters..."(1\*). In addition to its authority to regulate point source discharges of sewage and industrial waste, the SWCB has authority to require installation of facilities or other measures necessary to prevent escape of other wastes with potential to pollute state waters. The SWCB views existing law as an adequate basis for developing controls over nonpoint pollution sources (2).

Although this broader authority has been exercised in specific cases involving significant pollution problems, the SWCB has not attempted to implement a general regulatory program for nonpoint source control. Rather, the agency has adopted a nonregulatory nonpoint source control strategy. As an outgrowth of areawide waste treatment management planning conducted under provisions of the Federal Clean Water Act (3), the SWCB has developed best management practices (BMPs) for the major nonpoint pollution sources. The SWCB provides program coordination, but administration of this non-regulatory program involves state agencies in addition to the SWCB. For example, the Virginia Soil and Water Conservaton Commission (SWCC) has been designated as the lead agency at the state level for the agricultural component of the program and for the urban component in those urban areas undergoing development. Local governmental units, such as soil and water conservation districts, counties, and municipalities, also play important roles in the nonpoint control program.

In order to encourage compliance with voluntary BMPs, the state has employed cost sharing as a management device. After an initial effort that focused, during 1983, on encouragement of filter strips within selected areas of the state, including part of the bay's watershed, the 1984 session of the General Assembly appropriated \$750,000 for urban and \$2,500,000 for agricultural nonpoint pollution control within the bay's drainage area. The SWCC is responsible for administration of these funds. Planned uses of the funds designated for urban areas include cost sharing of technical specialist positions at the local governmental level and implementation of demonstration projects to determine the effectiveness of innovative urban BMPs. Unlike the urban case, part of the funds for agricultural nonpoint control is scheduled for direct cost sharing for implementation of BMPs by individual landowners. Individual cost sharing will be administered by the state's soil and water conservation districts.

In addition to the BMP program, another aspect of the state's waste management program affecting land use is the regulation of septic tank use (4). This program is independent of the general water quality management program and is operated through a joint effort of the state health department and the local health departments. Local health departments issue the required permits while

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\*Underscored numbers in parentheses refer to literature cited as references.

establishment of criteria and general regulatory responsibility are functions of state government.

Hazardous Waste Facilities Siting.--The Virginia Hazardous Waste Facilities Siting Act (HWFSA) (5) passed during the 1984 session of the General Assembly is a specialized measure applicable to a narrowly defined land-use activity. This act is significant in a discussion of land-use controls because its enactment acknowledged failure of the system of conventional controls to reach socially desirable decisions regarding the siting of hazardous waste facilities.

The HWFSA establishes a decisionmaking process for siting decisions that operates independently of most traditional land-use controls. Final authority for siting decisions is granted to a siting board structured to represent various interests relevant to siting decisions. Although the board has final authority, procedures established in the legislation encourage negotiated resolution of siting conflicts. A grant of approval from the board supersedes any local ordinance or regulation inconsistent with the terms of an approval. Board decisions can be appealed to the courts under provisions of the Virginia Administrative Process Act (6).

Land-use Regulation by Soil and Water Conservation Districts.-- A provision in the Virginia soil and water conservation districts law provides authority for regulation of land use by the state's soil and water conservation districts (7). This authority includes enactment of ordinances imposing such controls as requirements for structural measures, specifications of cropping and cultivation methods, and provisions for retirement of highly erosive areas from cultivation. However, such ordinances must be approved by a two-thirds vote in a required referendum. This measure apparently has never been employed and is not a factor in the current institutional structure for land-use control.

The Local Comprehensive Plan.--Virginia legislation provides that each of its counties, cities, and towns shall adopt a comprehensive plan (8). This plan is intended to indicate general recommendations for the development of the area covered. The following statement indicates the broad scope of considerations to be incorporated into the plan:

The comprehensive plan shall be made with the purpose of guiding and accomplishing a coordinated, adjusted and harmonious development of the territory which will, in accordance with present and probable future needs and resources, best promote the health, safety, morals, order, convenience, prosperity and general welfare of the inhabitants (9).

Although the enabling legislation is silent with respect to water quality protection, it does provide that the plan may include designation of areas for "conservation, recreation, public service, flood plain and drainage, and other areas . . ." (10). Thus, water quality protection appears to be a valid objective.

The comprehensive plan generally is not used as a direct regulatory device, but it acts to constrain development in certain ways. For example, it provides potential restrictions on future location of public facilities, and it also provides guidance for exercise of direct regulatory mechanisms such as zoning.

Zoning.--Zoning is a fundamental mechanism for control of land use. Virginia's enabling legislation (11) provides that any county or municipality may adopt a zoning ordinance. The general objective of zoning is ". . . to encourage local governments to improve public health, safety, convenience and welfare of its [sic] citizens . . ." (12). The specific considerations to be included in a zoning ordinance include this diverse list of factors:

Such ordinances shall be designed to give reasonable consideration to each of the following purposes, where applicable: (1) to provide for adequate light, air, convenience of access, and safety from fire, flood and other dangers; (2) to reduce or prevent congestion in the public streets; (3) to facilitate the creation of a convenient, attractive and harmonious community; (4) to facilitate the provision of adequate police and fire protection, disaster evacuation, civic defense, transportation, water, sewerage, flood protection, schools, parks, forests, playgrounds, recreational facilities, airports and other public requirements; (5) to protect against destruction of or encroachment upon historic areas; (6) to protect against one or more of the following: overcrowding of land, undue density of population in relation to the community facilities existing or available, obstruction to light and air, danger and congestion in travel and transportation, or loss of life, health, or property from fire, flood, panic or other dangers; (7) to encourage economic development activities that provide desirable employment and enlarge the tax base; and (8) to provide for the preservation of agricultural and forestal lands (13).

Although this list of factors does not specifically include water quality protection, the enabling legislation elsewhere provides for zoning to consider ". . . conservation of natural resources. . ." (14).

Subdivision Regulation.--Virginia law provides that each county and municipality shall adopt an ordinance for the orderly subdivision of land and its development (15). Enabling legislation establishes requirements for regulatory contents of local subdivision ordinances, including ". . . adequate provisions for drainage and flood control and other public purposes . . ." (16). Water quality protection appears implicitly to be included as an objective of subdivision regulation.

Erosion and Sediment Control.--Enacted in specific response to problems associated with soil erosion and subsequent sediment deposition, the Virginia Erosion and Sediment Control Law (ESCL) (17) is more explicitly focused on water quality protection than other land-use controls. The regulatory program created by the ESCL involves both state and local governments, with primary responsibility for program administration exercised by local governments.

The ESCL requires erosion and sediment control programs to be adopted by either the counties and municipalities or the state's soil and water conservation districts. The provision authorizing district programs applies only where counties and municipalities fail to act. At present, essentially all of the local programs are operated by counties and municipalities. The basic regulatory measure in the ESCL is the requirement that activities subject to its jurisdiction cannot be conducted without an approved erosion and sediment control plan. Approval requires that the

plan in question meet the standards and criteria of the local control program, which by law must be consistent with state guidelines. This requirement for approval applies to "land-disturbing activities," a term defined to exclude agricultural operations, activities such as surface mining covered by other regulatory programs, and a variety of small-scale activities such as construction of an individual single-family residence.

State government exercises several responsibilities under the ESCL through the Virginia Soil and Water Conservation Commission. The primary state responsibility is the establishment of guidelines for erosion and sediment control. The legislation requires the SWCC to develop guidelines containing conservation standards to include criteria, techniques, and methods for control.

The ESCL requires that local control programs be consistent with the standards contained in the state guidelines. The SWCC is responsible for development of local control programs wherever the appropriate soil and water conservation districts or local governmental units fail to act. However, the state does not administer such a program after development but turns it over to the appropriate political subdivision.

The state also has limited powers under the act regarding administration of controls. The SWCC is directly responsible for licensing land-disturbing activities in two situations: (1) state agency projects and (2) other projects involving lands under the jurisdiction of more than one program, provided the applicant elects to apply directly to the commission as opposed to the individual jurisdictions.

For other projects, the SWCC is authorized upon appeal to review local decisions where a local program is administered by a soil and water conservation district, but the review powers of the commission do not encompass decisions of counties and municipalities under the law. This potential review function has not become a significant commission responsibility since the counties and municipalities have adopted control programs in lieu of district administration. The commission is authorized to request the Attorney General to take legal action to compel local governments to carry out program provisions.

Although the SWCC's regulatory role is limited, the agency exercises other significant responsibilities with respect to local erosion and sediment control programs, primarily through the provision of education and technical assistance. This role is scheduled to expand within the drainage area of Chesapeake Bay, as a result of funds appropriated by the 1984 session of the General Assembly for addressing urban runoff problems. As noted previously, two planned uses of these funds are cost sharing for increasing local program personnel and development of demonstration projects for control of urban runoff.

Control of Development Affecting Wetland and Coastal Primary Sand Dunes.--Marine wetlands and primary coastal sand dunes have been given protection from development activities by establishment of special controls. The Virginia Wetlands Act (18) declares wetlands preservation to be the public policy of the Commonwealth and provides a wetlands zoning ordinance that can be adopted by counties and municipalities. This ordinance requires that use or development of wetlands (other than activities specifically exempted from the act) requires an authorizing permit from a wetlands board established to administer the ordinance.

Provision is made for the Virginia Marine Resources Commission (MRC) to administer wetlands controls in those localities not adopting the ordinance established in the Wetlands Act.

Even where a local government adopts a wetlands ordinance, state government exercises substantial authority regarding administration of controls. The MRC is responsible for guidelines to be used by localities in regulation of wetlands use. The MRC also has authority to review decisions of local wetlands boards. Such review can be conducted upon appeals from an applicant; the locality involved, where the Commissioner of Marine Resources requests review on the basis of the belief that a decision is inconsistent with the Wetlands Act or the MRC's guidelines; or where 25 property owners from the locality involved petition for review. Local decisions can be affirmed, modified, or reversed. This review process is a somewhat unique example of direct state oversight of local land-use decisions.

The Virginia Coastal Primary Sand Dunes Protection Act (19) provides similar controls over development affecting coastal primary sand dunes in designated localities. Because of its similarities with the Wetlands Act, this program will not be considered further here.

Taxation and Investment in Public Facilities.--The power to regulate the use of private property is perhaps the most conspicuous form of land-use control; but powers of taxation and provision of public services also have major impacts on land use and, therefore, should be considered as mechanisms of control.

Taxation can create an incentive for intensive development of property. From the perspective of the landowner, application of tax rates based on potential land use creates a tax burden discouraging non-intensive land use. The adoption of use-value assessments where tax rates are based on low intensity use can reduce the landowner's incentive to develop. Virginia's tax laws provide authority for localities to employ use-value taxation as a mechanism to influence land use (20). However, this action reduces local revenues from the affected property. This problem emphasizes the fact that the tax system of local government creates an incentive for localities to support development since tax revenues are thereby increased.

The pattern of providing public services, such as transportation and sewage facilities, exerts a major influence on land use. Decisions concerning public facilities are the primary responsibility of local government but are subject to substantial influence by state and federal governments because of the various programs of financial assistance and regulation. Such decisions have the potential to reinforce regulatory programs of land-use controls if the two decision-processes are coordinated.

#### Constraints on the Exercise of Land-use Controls

The preceding review of Virginia's primary land-use controls reveals several measures with potential for protection of water quality in the Chesapeake Bay. Collectively, these measures appear to provide control over most of the land-use activities that lead to nonpoint pollution. Yet, a significant nonpoint pollution problem currently exists, creating concern for the adequacy of existing controls.

Why have the existing controls apparently been inadequate as means to control the nonpoint pollution problem? This question is but one element of this broader question: Why land-use controls in general often seem unable to achieve stated social goals? Of course, neither question has a single answer. In order to evaluate the apparent ineffectiveness of controls applicable to the nonpoint pollution problem, several potential limitations on the exercise of existing controls need consideration. These limitations include possible inadequacies of the scope of provisions in existing legislation, constraints imposed by constitutions and other laws, limitations on the perspective of administrators, possible lack of coordination among separate control measures, and information deficiencies.

Scope of Existing Legislation.--The question of whether existing legislation is of adequate scope to provide protection of Chesapeake Bay water quality involves different issues in relation to the various legislative enactments. In the case of the state's water quality legislation, the primary question concerns the scope of activities that can be controlled. In the case of traditional land-use controls, the relevant question is whether water quality protection is a valid objective for the application of controls.

The preceding review of Virginia's water quality legislation indicates that its scope is broader than control of point source waste discharge. However, this legislation has not been employed as a source of authority for a broad program of land-use controls; consequently, the full extent of its scope, together with any limitations, has not been defined. The existence of such potential limitations has been illustrated in a response of Virginia's Attorney General regarding power of the SWCB to control sediment. The Attorney General noted that ". . . the deposit of excessive and unnatural quantities of sediment in State waters would constitute pollution for the purpose of the State Water Control Law" (21). However, the Attorney General indicated that total control of the sedimentation problem would likely exceed the resources and authority of the agency. Nevertheless, the authority to control water pollution is broad, and the scope of existing legislation does not appear to be a major constraint.

Determination of whether traditional land-use controls encompass water quality protection as a valid objective requires separate consideration of the various controls. While enabling legislation for some controls (such as erosion and sediment control) shows direct concern for water quality protection, certain other statutes (such as enabling legislation for zoning and subdivision regulation) appear to have been enacted without explicit concern. But even in these cases where legislation makes no specific references to water quality, statutory language appears to be broad enough to include the water quality objective. The question of whether zoning can be employed to protect water quality is currently an issue in litigation between Fairfax County and landowners. The Fairfax County Circuit Court has ruled that such use is valid, but the decision has been appealed to the Virginia Supreme Court.

As the existence of this current Fairfax County judicial proceeding indicates, some uncertainty concerning the scope of existing legislation continues to exist; but a general assessment of this legislation suggests that adequate authority exists to protect the bay from nonpoint sources of pollution. Water quality legislation appears to encompass land-use controls at least to some extent, and traditional land-use controls appear to include water quality within their objectives.

Therefore, adequacy of legislation coverage does not appear to be an important reason for existing water quality problems in the bay.

Impact of Constitutions and Other Laws.--Because of the potential scope and magnitude of the impacts of land-use controls, their exercise is constrained by constitutional provisions and other statutes designed to achieve other social objectives. Especially significant are federal and state constitutional safeguards of property rights and individual liberties. These safeguards prohibit regulation of land use to the extent that the owner is unable to make practical use of the property, a situation traditionally considered an unconstitutional taking. Another constitutional provision frequently asserted in opposition to land-use controls is the guarantee of equal protection under the law. This provision establishes limits on discriminatory actions such as exclusionary practices that have a disproportionate impact on lower income groups. Another potential restriction is federal anti-trust legislation that has some applicability to actions by local government (22). This restriction potentially could be invoked if local decisions have a major adverse effect on business competition.

The extent of the constraint imposed on exercise of land-use controls by these provisions varies over time and among judicial systems. The Virginia Supreme Court during its early considerations of the validity of local land-use controls adopted the position that local government has substantial discretion in controlling land use. Local ordinances were given a presumption of validity, thus imposing a significant burden on any challenger. Court decisions during the early period generally upheld local regulatory actions (23).

According to a recent study (24), this position has undergone major change in more recent years. This analysis finds that the state supreme court has increased its level of scrutiny of local decisions and generally decreased the deference granted to local discretion. The study suggests that the court's review process has become so broad as to constitute judicial exercise of the zoning function and the effective repeal of the enabling legislation granting local authority (25).

With regard to the substance of the court's recent decisions, the study finds a high degree of protection for the rights of private land developers. The court has frequently overturned local controls in conflict with development plans (26). This emphasis on maximizing private economic return from land development appears to constitute a narrow view of the legislative criteria for land-use controls. The position indicated by these decisions suggests that the court may take a restrictive view of the use of land-use controls for achieving environmental quality goals if such use involves a substantial impact on development.

Perspective in Program Administration.--The existence of adequate legislative authority creates the potential for water quality protection. The extent to which protection is realized depends on the actual administration of programs authorized by the legislation. The issue of incentives to apply controls is an important issue whenever significant discretionary authority exists. This issue is especially important with respect to administration of land-use controls by local governments since enabling legislation provides substantial discretion regarding the content and administration of controls.

Incentive is affected by the perspective of the decisionmaker. Assessments of costs and benefits associated with a particular activity may be substantially different from the local and state perspectives. The state takes a broad (although not necessarily comprehensive) view while individual localities focus primarily on those benefits and costs that accrue within local political boundaries. Localities have an inherent tendency to exercise land-use controls to prohibit any activity whose costs occur locally while benefits are widespread. Herein lies the source of the traditional difficulty of siting certain waste disposal facilities, particularly those from hazardous wastes. Conversely, local governments tend to view permissively any activity with concentrated local benefits and widely dispersed costs. Many traditional land-use activities that generate nonpoint pollution are likely to fall into this category.

The tendency of local government to ignore land-use impacts occurring outside local boundaries is a major obstacle to effective use of locally administered land-use controls for protecting water quality in Chesapeake Bay. To the extent that local discretion exists, adoption and aggressive enforcement of controls over the sources of nonpoint pollution are unlikely because of the distribution of costs and benefits that would result from the controls. While the costs of controls would be concentrated locally, the benefits would be widespread and may have limited local effect. A further disincentive to local action is the number of localities that would have to take similar action for a significant benefit to the bay to be realized. Lack of assurance that the necessary complementary actions would be undertaken by other local governments tends to prevent action by any individual locality.

There is special significance in the fact that current enabling legislation for locally administered land-use controls does nothing to encourage a perspective broader than local political boundaries. Virginia code provisions concerning local planning and land-use controls declare a general legislative intent". . . to encourage local governments to improve public health, safety, convenience and welfare of its [sic] citizens . . ." (27). This exclusive focus on local benefits and costs appears consistent with the intent of current legislation.

Coordination Among Separate Controls.--The accomplishment of an objective through a somewhat decentralized system of programs and agencies generally requires special coordination if the effort is to be successful. In the case of protecting Chesapeake Bay water quality by application of land-use controls, the institutional framework consists of several components that require coordination. Since a focused effort to protect the bay from nonpoint pollution is a relatively new undertaking, an attempt to identify coordination problems is premature and requires speculation. However, coordination is a potentially important concern even if interstate issues are neglected. Several state agencies are involved in the nonpoint control effort, and several local programs are components of the overall protection effort. An especially significant need at the local level is coordination among regulatory efforts, taxation, and provision of public facilities. Without coordination, the efforts in one area may be nullified by the impact of decisions in another.

Information Adequacy.--Although much information has been acquired in recent years concerning nonpoint pollution and alternative control strategies, much remains to be learned. The SWCB has adopted a voluntary nonpoint control strategy because of the

absence of a demonstrated cause and effect relationship between land use activities, nonpoint source pollution, and water quality problems in State waters and also due to the lack of documentation concerning the effectiveness of BMPs to reduce nonpoint source pollution... (28).

This statement is an acknowledgment of continuing uncertainties regarding basic aspects of the nonpoint pollution problem and possible solutions.

These uncertainties also impact local programs. The traditional tendency of local government to disregard the diffused water quality effects of land-use decisions can be explained at least in part by lack of knowledge concerning such effects rather than wholly on the basis of lack of concern. Administration of local control programs also is hindered by inadequate information concerning the effectiveness of alternative BMPs.

### Conclusions and Recommendations

This overview of Virginia's land-use controls reveals the existence of relatively comprehensive control mechanisms with potential to address the nonpoint pollution problem affecting the Chesapeake Bay. However, a variety of constraints of differing severity reduce the effectiveness of these controls. If this assessment is accurate, the primary need is not for major new legislation but for improved implementation of existing legislation.

Activities already underway have potential to remedy certain problems. Of special significance are efforts to increase information by such means as demonstration projects to assess effectiveness of nonpoint pollution control techniques. Also important are educational and information dissemination programs designed to increase application of existing knowledge in the administration of land-use controls. These efforts will increase awareness of the nonpoint pollution problem and technical capabilities for carrying out management programs.

Addressing certain deficiencies will require changes in legislation. One beneficial change would be the addition of language to enabling legislation for local land-use controls explicitly recognizing water quality protection as an objective wherever such language does not now exist. The need for this change in the case of zoning law will be determined by the decision in the current litigation involving Fairfax County. Addition of water quality protection as an explicit objective will be critical if the Virginia Supreme Court holds this objective not to be included at present. Even if the court finds water quality protection is implicitly included in enabling legislation for zoning, addition of explicit provisions in zoning law and other legislation for land-use controls is still desirable as a means to increase emphasis placed on this objective. The above-cited study of Virginia Supreme Court decisions concerning local land-use controls indicates little attention to objectives other than maximizing returns to developers. Amendment of the legislation to emphasize other objectives may modify the court's view of the public welfare as embodied in land-use controls.

Another more fundamental change needed is amendment of enabling legislation to broaden the perspective employed in the administration of local land-use controls. Although some modification of the division of powers between state and local

governments is needed, radical revision does not appear necessary. Local government is the appropriate level for the exercise of land-use controls, provided that mechanisms exist to assure adequate consideration of impacts extending beyond local political boundaries.

A first step in achieving the needed change is amendment of current enabling legislation suggesting that a local government's definition of public welfare is limited to its own inhabitants. This concept is inconsistent with the reality of physical systems that transcend political boundaries and should be abolished by explicit legislation providing for consideration of impacts external to individual localities.

While this change is necessary, it may not be adequate in itself if consideration of external impacts is left within the discretionary power of local government; additional mechanisms for direct state input may be required. Existing land-use control programs involve a range of provisions for state involvement extending from essentially no direct state participation (as in zoning) to state administrative review of local decisions (as in the wetlands protection program). The erosion and sediment control program represents a compromise approach where a state agency provides detailed program guidelines for localities but exercises no administrative review of local decisions. Increased state activity in such areas as education and cost sharing made possible by 1984 appropriations should increase the effectiveness of this program and indicate the general utility of the compromise approach involving limited state regulation. If the program does not achieve desired results, the need will be indicated for increased state involvement in actual administration of this program as well as in other land-use controls.

The state's agricultural lands, which have been identified as an important source of Chesapeake Bay pollution, pose a special management problem from the institutional perspective. At present, these lands generally are not subject to direct land-use controls by either state or local governments. The current program of cost sharing for implementation of BMPs is a reflection of the lack of other controls and perhaps recognition of a fundamental right of landowners to create adverse environmental effects if engaging in agricultural activities. Considerable uncertainty exists concerning funding and the ultimate effectiveness of this program, suggesting the possibility that a different approach may be required in the future. If a regulatory approach becomes necessary as a replacement for or a supplement to the cost-sharing program, state administration of a regulatory BMP program under water quality legislation appears to be the most likely institutional option. However, the feasibility of such an approach remains to be determined.

This review of problems and potential remedies illustrates the obvious fact that no single, simple solution exists for the nonpoint pollution problem affecting the Chesapeake Bay. Just as there is no quick technological fix, there is no quick institutional fix. But progress appears possible through a combination of increased knowledge concerning nonpoint pollution and control techniques and institutional modification to improve the effectiveness of management efforts. Such accomplishments are not easily achieved. Improvement of knowledge basically requires money while institutional modification involves much political controversy. But the magnitude of the problem suggests little choice but to proceed because the alternative is likely to be even less desirable.

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## LAND APPLICATION AS AN ALTERNATIVE FOR TREATMENT OF MUNICIPAL WASTEWATER

By Donald J. Epp\*

The more we learn about the impact of human activity on the Chesapeake Bay, the more we realize that something must change. If we want to continue to enjoy the food, recreation, and esthetic wonders of this magnificent bay, we must alter the way we use both the bay itself and its watershed for commerce, transportation, waste disposal, and building space. As scientists from a series of disciplines have studied conditions in the Chesapeake Bay and other estuaries, we have learned that its ecosystem is affected not only by activities in the waters and marshlands of the bays, but also by activities in the entire upland watersheds that drain into the bay. We are learning that the health of the bay is determined to a large extent by the quality of the water that enters into it. This paper examines one important aspect of managing the water quality of streams that enter the bay--the treatment of municipal sewage.

During the past decade of environmental concern, conventional methods of treating municipal sewage have not always been acceptable. In the jargon of the Water Pollution Control Act, municipal sewage plants that use secondary treatment and that discharge the effluent into a stream, lake, or estuary are point sources of pollution. In some cases the biochemical oxygen demand (BOD) levels of the effluent are judged to be too high for the receiving waters, but more frequently the nitrogen and phosphorus levels cause excessive rates of eutrophication.

Disposing of the effluent is not the only problem facing municipal treatment plant operators. Primary and secondary treatment produces sludge that must be placed somewhere. In the past, the city dump or a vacant field frequently sufficed as a sludge disposal area. Bigger coastal cities dumped it into the ocean. A few communities incinerated it. All of these methods have been found to pose environmental hazards and either have been eliminated or severely restricted as options.

In the search for alternative ways to treat sewage and to find acceptable ways for disposing of effluent and sludge, we have come to realize that their disposal is very expensive. If society must rely on chemical-physical techniques for removing nitrogen and phosphorous from the effluent, treatment costs will skyrocket. Landfills that meet the requirements for disposal of sludges are scarce, and transportation to acceptable locations is expensive. Confronted with this backdrop

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of expensive technological alternatives, managers have rediscovered the original waste disposal technique--land application. Research has been needed to develop ways of applying wastewater (both the effluent part and the sludge part) to the land, to insure that harmful effects do not occur, and to determine the economic feasibility of this alternative. This paper reviews briefly some of the research conducted at The Pennsylvania State University (Penn State) and elsewhere on land application of wastewater. The research suggests that land application is a realistic alternative for many communities.

### Land Application of Effluent

The pollutants of most concern in effluent from secondary treatment plants are nutrients, specifically nitrogen and phosphorus. These nutrients stimulate the growth of aquatic plants and algae, in many cases leading to reduced levels of dissolved oxygen in the receiving stream or lake. Reduced levels of dissolved oxygen create serious odor problems as well as cause fish to die. The very substances that are pollutants in the water, however, are valuable when applied to cropland or forests. Results from the Penn State Wastewater Demonstration Project illustrate the response of several important agricultural crops to different levels of effluent application (table 1).

Table 1.--Crop response to effluent application

Crop	Rate of application	Yield
	Inches/week	Per acre
Alfalfa silage	1.0	8.7 tons
	2.0	9.9 tons
Corn grain	1.0	78.2 bu.
	2.0	80.1 bu.
	3.0	56.2 bu.
Corn silage	1.0	16.0 tons
	2.0	16.4 tons
	3.0	11.5 tons
Reed canarygrass silage	1.0	7.8 tons
	2.0	11.7 tons
	2.5	13.5 tons

Source: Young, Bradley and Epp, 1978

The results in table 1 also illustrate part of the management problem when applying effluent to crops. As more effluent is applied, more nutrients are applied, and, up to some level of application, yields increase. But, some crops

cannot tolerate high levels of water application, after a certain level of application, yields are hurt. Both corn grain and corn silage yields increase as irrigation rates rise to 2.0 inches per week but yields fall at higher rates of irrigation. To be most effective the manager must produce crops that remove nutrients from the water as it moves through the soil, that may be sold to offset at least some of the costs, and that can accept wastewater application for most, if not all, of the year.

Several models have been developed to assist managers in choosing crop and irrigation systems for effluent application. In a study at Penn State, costs were examined for various cropping systems for a treatment plant discharging 3-million gallons per day (mgd) of effluent. Such a plant would serve a community of 25,000 to 30,000 people. Under the climatic and soil conditions found in central Pennsylvania and using crops tested at the Penn State Wastewater Project, producing reed canarygrass silage and irrigating the year around gave the lowest annual cost. If 2.5 inches were applied each week, 309 acres of reed canarygrass would be needed to handle the effluent. Other crops produce greater crop values but effluent can only be applied for about 7 months of the year. Additional storage must be built to hold the effluent during the other 5 months and additional land must be obtained to apply the stored effluent the following season.

Several application restrictions were applied to the wastewater project optimization program to examine their effects on costs. A two-inch application restriction was considered, as was an irrigation season limited to 285 days per year. The latter restriction avoids application during the winter and coincides with the recommendation of the U. S. Environmental Protection Agency (EPA) for land application systems in central Pennsylvania. The system was restricted in every case so that nitrate concentrations in the perculant below the root zone were projected to be fewer than 10 parts per million, the standard for drinking water.

The results of examining these restrictions are shown in table 2. Reed canarygrass silage was the crop producing the least cost solution in all cases.

Table 2.--Minimum cost solutions, three sets of restrictions

Months irrigated	Rate of application	Acreage irrigated	Total costs
	Inches/week	Acres	Dollars
Basic solution			
12.0	2.5	309	\$493,000
Irrigation rate not more than 2.0 inches/week			
12.0	2.0	387	\$536,000
285-day irrigation season			
9.33	2.5	396	\$624,000

Source: Young, Bradley and Epp, 1978

When the application rate was restricted to 2 inches per week, the number of acres needed increased by 78, to a total of 387, and the annual cost increased by \$43,000. Limiting the irrigation season to 285 days, but permitting irrigation rates up to 2.5 inches per week, created the need for a larger system (396 acres) and increased costs by \$131,000 per year above the basic solution.

While the results shown by these studies apply to Pennsylvania conditions, similar results can be expected for most areas draining to the Chesapeake Bay. Some of the crops studied in Pennsylvania would not be chosen for Virginia conditions. For example, bermuda grass would be used in Virginia instead of the reed canarygrass studied in Pennsylvania. The two grasses have many similar properties, and it is likely that most effluent irrigation systems in southern Virginia would choose bermuda grass for at least part of the irrigation area. If crops were grown that were suited to long irrigation seasons (such as bermuda grass), a season of 310 to 325 days probably could be used in the southern parts of Virginia. The shorter and less severe winter would permit longer application seasons than are recommended for central Pennsylvania. The shortened off-season requires smaller storage facilities and, thus, less additional land for subsequent application. Cost would decline as a result.

Some portions of the Chesapeake Bay watershed will not be suitable for land application of wastewater. For example, the sandy soils and high-water tables found in parts of the Delmarva Peninsula would probably be unsuitable or at least would require extra management effort to avoid contaminating the groundwater with nutrient laden percolant. Tight clay soils with slow percolation also are unsuited for land application systems. While the soils in some locations in the watershed may be unsuitable, most agricultural areas are well adapted to the land application method of wastewater treatment.

Another factor that may modify application of the Penn State research results is the federal government program of financial assistance in building sewage treatment facilities. The studies at Penn State assumed that federal subsidies paid 75 percent of the capital costs for conventional treatment systems and 85 percent for land application systems. While this is the current policy, proposals are being considered that would reduce this subsidy to 50 percent of the capital cost or even eliminate the federal subsidy entirely. If such proposals are adopted, the cost to local governments for constructing sewage treatment facilities will increase regardless of the type of system. However, what effect this would have on the relative cost of land application and advanced physical-chemical treatment systems is not clear. In areas where land is very expensive (say, several thousands of dollars per acre), or a cropping system is chosen that requires large amounts of storage and, consequently, a large application area, or where the wastewater must be pumped a considerable distance or up a considerable lift, land application without a capital-cost subsidy may be more expensive to the local authority than would advanced treatment using physical-chemical methods. Analysis of specific cases will be necessary if changes are made in the federal program. Even so, I would expect most communities to find land application to remain competitive.

Thus, while the soil and topographic features of a specific site must always be considered before choosing land application, and while the crops grown and the irrigation season may differ from those where the studies have been conducted, I would expect the basic conclusions of the Penn State studies to remain valid for the Chesapeake Bay area. These conclusions are: (1) that costs of land application

systems can be expected to be substantially below other alternatives for small- to medium-sized treatment plants and (2) that costs will be reduced if the cropping system chosen permits year-round application of effluent at high rates of application.

### Land Application of Sludge

Depending on the nature of the sewage treated, the sludge from municipal wastewater treatment can be very dangerous or very valuable as a soil additive. Many of the nutrients and all of the organic matter in the wastewater that is not digested in the treatment process goes into the sludge. These ingredients are useful when applied to farmland. The sludge also contains any heavy metals and many of the organic chemical pollutants in the sewage. The proportion of these constituents that are in sludge must be known and carefully controlled as this information is important in determining where sludge can be applied.

The easiest sludge to consider for farmland application is that coming from systems that serve exclusively residential communities. Most of the seriously contaminated sludges come from treatment of industrial wastes, although copper and lead may be found in sludges from residential areas.

Farmers in many parts of the nation already use municipal sewage sludge as a source of plant nutrients and as a way to increase the organic matter in the soil. A recent study in Pennsylvania showed that typical sludge was worth about \$10 per ton of dry matter when applied to the field by the sewage treatment authority at a time convenient for farm operations. This value assumed an average dairy farm in central Pennsylvania and price relationships as experienced around 1980. These conditions were typical of current practices in Pennsylvania, but may not hold for conditions where large numbers of sewer authorities seek to apply sludge to farmland. If an authority applied a liquid sludge that contained 9 percent nitrogen (dry matter basis), the value of the sludge to the farmer was a little over \$21 per ton of dry matter. Nine percent represents near the maximum nitrogen content available in sludge.

The Pennsylvania study assumed a sludge with extremely low levels of heavy metals and organic contaminants. This is the type of sludge now applied to farmland in Pennsylvania, and the need to consider loading limits for various contaminants is eliminated. If sludges from a wider range of treatment plants are to be considered for farmland application, care must be taken that various heavy metals and organic compounds are controlled. Soil scientists and other researchers looking at the health aspects of these contaminants formed a regional committee in the Northeast to develop recommendations about annual and lifetime loading limits for various constituents. These limits will serve to reduce the damage to plant production and marketability that would result from excessive application of potentially harmful constituents in sludge. Since these recommended limits will vary greatly for regions with different soils and climate, I anticipate that similar recommendations will be developed for each region of the country.

Another use of municipal sludge that is gaining in popularity is for the revegetation of radically disturbed sites. The most widely known use of this type is for revegetating stripmined areas, but the technique may also be used along new highway construction, shopping center, or industrial sites where it may be difficult

to establish a vegetative cover. The advantage of these sites for sludge disposal is that the vegetation grown usually does not enter the human food chain. Consequently, the loading limit for some heavy metals and organics can be increased. Thus, sludges that may not be suitable for farmland application can be used on disturbed sites intended for forest or other non-food production uses.

### Community Acceptance of Land Application

One of the biggest obstacles to land application of effluent or sludge is gaining the acceptance of people in the receiving area. The concerns of citizens in the area generally fall into four broad categories.

The first major category of concern is with the health hazard that sludge or effluent application might present for the community. These concerns arise in large part because many people do not realize that what is applied to the land is not raw sewage but the residual after substantial treatment has been done to kill disease organisms. A combination of educational programs and safety precautions, including buffer zones and monitoring, usually overcome objections relating to disease.

The second category of concern is related to the first, but is more difficult to counter. People are usually concerned about hazardous contaminants in the effluent or sludge that may have long-lasting effects on the quality of the land or water in the area. Although the general public may not have a scientific knowledge of heavy metals and organics, most people know that these substances can cause terrible health problems that can affect a large geographic area. Furthermore, many people realize that the health effects may take a long time to appear but once they do, it may be impossible to clean up the contaminated soil and water. Rather than run that risk, people would rather not have effluent and sludges spread in their communities. This source of concern is a legitimate one, because sludges can contain heavy metals and organic pollutants that will cause long-term damage. At the same time we know that few, if any, sludges are completely free from all possible contaminants. We also know that small amounts of these contaminants are present in many sludges, but that no harmful effects have been noted from long-term exposure to such low concentrations of the pollutants. Wise management of wastewater requires that sludges with very low concentrations of heavy metals and organics be considered for land application under careful controls. The problem for discussion and education is to determine the acceptable level of risk and manage the sludge application to satisfy everyone that care is being exercised.

A third category of concern about land application, especially of sludge, is the hauling of sludge to the application site. During application periods large tank trucks or dump trucks may be traveling rural roads. This increased traffic of heavy trucks may be objectionable to some people. On certain road surfaces it may cause extra dust and noise. If the hauling is not done carefully, sludge may be spilled on the road, creating unsightly and sometimes dangerous conditions. Most of these problems can be resolved with adequate planning and careful operations. Hauling routes and times can be planned to minimize congestion and conflict with other road users. Well maintained equipment and operators trained to be sensitive to prevention of noise and spillage can usually prevent serious objections.

The final broad category of concern frequently expressed about effluent irrigation proposals is their impact on local tax revenues and services. Some

proposals for land application of effluent have called for thousands of acres in public ownership, and the question that arises is, What would this do to tax revenues of schools and local governments?

Researchers at Penn State University examined a proposed land application program to determine its impact on revenues and expenditures of local governments and school districts. The plan called for over 15,000 acres of land in 5 sites to be devoted to irrigation. The people living on the land would be relocated, allowing some roads to be closed. The study examined the effect on revenues of schools and governments from public acquisition of the land and the likely effects on expenditures if the people who moved off of the land located within the same municipality or school district.

The results of this study are shown in table 3. Most of the impact is borne by one school district, although one of the municipalities had a comparable percentage impact on net revenues. Smaller projects, involving fewer than 1,000 acres probably would have a little effect on local governments and schools. A 1,000-acre area could serve 50,000 people in most areas of the United States.

Table 3.--Fiscal impact of a land application program

Municipality	Revenue lost	Expenditure reduction	Net loss	Percent of 1972 revenues
1	\$ 21,471	\$ 11,448	\$ 10,023	10.6
2	5,099	3,780	1,319	4.4
3	2,203		2,203	3.2
4	2,836		2,836	3.9
5	665		665	0.9
School district				
A	\$195,559	\$ 29,100	\$166,459	9.1
B	22,816		22,816	1.9

Source: DeTullio and Epp, 1979

#### Benefits Accompany the Problems

Remembering that land application programs provide benefits to the local area as well as problems and concerns is important. The most obvious benefit is the reduced cost of sewage treatment services. This benefit is received by the residents of the city or town served, but it also may be attractive to certain industries. A study of sewage treatment for poultry processing plants showed that they could obtain substantial savings by jointly treating their wastewater with the local community. From table 4, it can be seen that a small poultry plant could expect to spend 157.9 cents per thousand gallons of wastewater treated if it treats only its own wastes. By joining with a city of 20,000, the studied plant could reduce costs by more than 50 percent. A large plant could save about 30 percent.

Table 4.--Average total costs (in cents per thousand gallons) of center-pivot irrigation systems with activated sludge treatment

Item	Population served			
	Poultry plant only	Number of people		
		5,000	10,000	20,000
Cents per 1,000 gallons				
Domestic wastewater		128.2	97.9	77.5
Joint with:				
Small plant	157.9	103.0	88.2	74.7
Large plant	99.7	79.6	74.9	68.4

Source: Epp, Young and Rossi, 1982.

The municipality would also save by joining with the poultry plant. Savings in sewage treatment costs can make a community attractive to industries with large volumes of sewage to treat. New industries would provide employment opportunities for people from the surrounding areas as well as the city served by the sewer.

Sludge applied to farmland provides plant nutrients at much lower cost than commercial fertilizers. Sludge applied as part of a revegetation program for strip-mined or other radically disturbed sites helps to reclaim and beautify the area.

Another advantage for the local area is the cleaner streams that result from applying the effluent to the land. In addition, the percolating water will increase the availability of groundwater. In some regions, this is a significant advantage. Effluent spray sites also provide open space. In addition to a scenic area, they may be opened to public hunting or other compatible recreational uses.

In sum, land application programs for effluent and sludge application can provide significant benefits to the application area. The challenge is to devise programs that balance the disadvantages with benefits so that both the users of the sewer system and the residents of the application area realize a benefit.

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## SELECTED INDUSTRIAL/COMMERCIAL DEVELOPMENT IN THE HAMPTON ROADS AREA

By Theodore (Ted) B. Ray\*

As Manager of Environmental Engineering for the Newport News Shipbuilding and Dry Dock Company, one of my duties is to define the need for, secure the necessary permits, contract for, and supervise dredging operations at Newport News Shipbuilding. Over a period of years, I have probably been involved in more dredging in the Hampton Roads-lower James River area than anyone outside of employees of the Corps of Engineers or a major dredging contractor. I assume that it is because of this activity that I have been asked to present to you the scope of the shipbuilding and coal-loading industries within the Hampton Roads, arguments for dredging selected areas in the Roads, and the effects of dredging in the Roads and closely-related estuaries.

### Shipbuilding Industries

I will discuss the shipbuilding and repair industry; first, and briefly, on the national front, and then narrow my views to the Hampton Roads area. My purpose will be to show you that although the economy of the nation as a whole declined over the past decade, and shipbuilding in particular, shipbuilding in the Hampton Roads has been a live and viable aspect of the local economy.

The Maritime Administration monitors employment and capabilities of the shipbuilding and repair industry. While over 200 privately-owned firms of varying capabilities are involved in repairing ships in the United States, only 70 shipyards are capable of dry docking vessels 300 feet in length and over. For ships this size the U. S. shipbuilding and repair industry is currently operating a total of 95 floating dry docks, 55 graving docks, and several marine railroads. The larger major shipyards usually combine repair, overhaul, and conversion with shipbuilding capabilities and employment usually numbers in the thousands. Small repair organizations, generally referred to as topside repair yards have no drydocks, only shops and pier facilities, and often employ fewer than 100 people.

Total shipyard employment for the country has been on a downward trend for some years. Total employment of 170,200 in 1978 has fallen to about 153,000 in late 1983. In September 1983, 101,145 of that number were employed in 26 major shipyards, an average of about 4,000 per yard.

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Under the definition of major yards being those capable of drydocking a vessel of 300 feet or larger, Hampton Roads has three major private shipyards, Metro Machine Corporation, Norfolk Shipbuilding and Dry Dock Corporation, and Newport News Shipbuilding and Dry Dock Company.

Metro Machine.--Prior to 1982, Metro Machine was limited to topside work. In 1982 this repair yard added a 14,000-ton floating drydock. This is still a small company, but it is aggressive, growing, and continuing expansion plans.

Norfolk Shipbuilding.--Norshipco is composed of three plants, known as Berkley, Brambleton, and Southern. It is one of the larger ship repair companies on the east coast and is capable of constructing large oceangoing vessels. Its major facilities consist of three marine railways and four floating drydocks, the largest of which will accept a vessel 960 feet long by a 160 foot beam and with a lifting capacity of over 54,000 tons. Norshipco is an aggressive and growing company with very good equipment and facilities. In 1982 the company completed a \$4.5 million modernization program. Norshipco's employment roll tends to fluctuate from a base of 2,540 (1980 and 1982) to over 3,000 (1981 and 1983).

Newport News Shipbuilding.--Newport News Shipbuilding is the largest shipbuilding complex in the Free World. The company occupies approximately 475 acres with a waterfront some two miles long with close to 600 buildings, the company has eight piers, four drydocks for repair, two inclined building-ways (each of which can support two submarines simultaneously), three graving docks for building or repair, and two outfitting berths (one 1,670 feet long and the other 950 feet long).

In 1972 the company received the final permits to bulkhead and fill at the North Yard to expand its shipbuilding capabilities. A part of that project was the largest graving dock in the United States. It is 250 feet wide by 1,613 feet long and has a depth of 33 feet at the sill. Originally designed for the construction of large liquid natural gas tankers and even larger oil tankers the facility seemed doomed to idleness when the oil crisis following 1973 resulted in cancellation of orders for vessels. The company set its goals for other uses for the facility and has now converted all parts of the facility; the graving dock, the fabricating ships, and the outfitting berths to include the building and outfitting of Navy ships. The methods and techniques used in this new facility makes it possible to reduce the construction time of the aircraft carrier now under construction by a whole year.

Newport News Shipbuilding has built, converted, or jumboized over 700 ships, including 23 aircraft carriers, 33 nuclear powered submarines, and 121 other surface ships for the Navy. Commercial vessels include 71 cargo ships, 84 tankers, 62 passenger vessels (the famed superliner UNITED STATES is an outstanding example), and more than 60 other ships. It pioneered the jumboizing concept, and since 1957 has completed 33 such operations. This shipyard has fully integrated facilities for the construction and repair of merchant and naval vessels. It is the only U. S. shipyard capable of designing, building, repairing, and refueling the full range of nuclear powered aircraft carriers, cruisers, and attack submarines for the U. S. Navy. The company also has the capability and expertise to build a wide range of industrial products ranging from pumps and water turbines to components for commercial power plants, conventional and nuclear powered. A point of interest is that the shipyard designed, built, and supervised installation of a significant portion of the water turbines in use throughout the world.

Newport News Shipbuilding is a strong and still growing company. It has had a continuing multimillion-dollar capital improvement plan, rebuilding, or renewing old facilities and building new ones. In July 1983, the company announced plans to build a new \$300 million submarine construction and repair complex. This project will involve four new building-ways, a major construction facility under roof and the addition of a new floating dry dock for launching submarines.

It is interesting to look at the recent employment levels at Newport News, a period marked by declining employment nationwide. In 1980, the employment role was at 22,900 and has subsequently risen to 24,000 in 1981, to 26,000 in 1982; and to about 28,200 in 1983 where it will probably level off. In addition to employees of the shipyard, we also have some two to four thousand additional personnel including vendor representatives, civilian employees of the Navy under the Supervisor of Shipbuilding, and Navy crewmen of vessels under construction or repair. This shipyard is a city in itself.

Navy.--We cannot adequately consider the scope of the shipbuilding industries in the nation or in Hampton Roads without some mention of naval shipyards. The Navy has nine major shipyards. One of the largest of these is the Norfolk Naval Shipyard in Portsmouth, Virginia. This facility has seven graving docks which can be used for building or repair. It is an old facility, but is reputed to be in good condition. I cannot tell you the level of employment, but I would guess that it is closer to that of Newport News Shipbuilding than to that of Norshipco.

Consider that Marad reported that in 1983 about 101,000 people were employed in 26 major shipyards. Then note that two of those, Newport News Shipbuilding and Norshipco accounted for 31,340 or approximately 31 percent of those. I believe we can say that shipyards make a significant contribution to the economy of Tidewater Virginia and to Virginia as a whole.

### The Coal-loading Industry

The coal-loading industry has been a major part of the Hampton Roads' waterfront for a long time through the facilities of the Chesapeake and Ohio (C & O) Railroad in Newport News and the Norfolk and Western (N & W) Railway in Norfolk. The C & O operates two modernly equipped piers for handling coal and petroleum coke. They have an annual dumping capacity of over 30-million tons. The C & O facilities will accommodate 150,000-ton coal carriers and load them at a maximum rate of 9,000 tons per hour. Consider that in light of Tennessee Ernie Ford's song of loading 16 tons per day. The N & W facilities on Lamberts Point are the largest, and most complete in the world. Completed in mid-1963, the facility can accommodate about 7,500 loaded coal hopper cars and has a design capacity to load 16,000 tons of coal per hour. Over 124,000 tons has been loaded onto one vessel. Some of these vessels approach 1,000 feet in length and 145 feet in width.

Massey Coal Terminal, at Pier 9 in Newport News, has been the new kid on the block. The facility was started in April 1981 and completed in the first quarter of 1983. Differing from the C & O and N & W facilities, Massey will dump the coal in 12 piles of up to 110,000 tons each and then retrieve it to mix and blend from two or more piles and load it onto vessels at up to 8,000 tons per hour. The facility will load vessels from 8,000 to 175,000 dead weight tons displacement and is rated as having an annual capacity of 12-million tons per year.

The newest coal-loading facility is the Dominion Coal Terminal in Newport News. Construction started on June 1, 1982, and it is (or was) scheduled for completion in the second quarter of 1984. It has a storage site to accommodate 1,200,000 tons in piles. Coal will be reclaimed from the piles and blended and then loaded at an average rate of 6,000 tons per hour onto vessels up to 188,000 dead weight tons displacement. The facility will have a rated annual capacity of 12 million tons.

The two new facilities raise the total loading capabilities of port facilities in Hampton Roads to 90-million tons per year. That is a lot of capability, and it represents a lot more capability than the volume of coal being shipped.

Coal shipments account for the major tonnage of exports from the Hampton Roads area. Of the six leading ports on the East Coast, Hampton Roads has led in total export tonnage over the past seven years with its volume of export tonnage growing from 22,518,500 tons in 1978 to 66,488,000 in 1982. In other terms, Hampton Roads' share of export tonnage rose from approximately 45 percent to 65 percent of the total east coast tonnage. During these same years the export tonnage of coal increased from 14.5 million tons in 1978 to 53.0 million tons in 1982. Total shipments and coal shipments fell to considerably lower levels in 1983. For instance, export coal dropped to 35.48 million tons.

Now lets consider the number of cargo vessels entering or leaving Hampton Roads each year. In 1977 the total number was 3,763 and by 1982 that total had dropped to 3,580. Consider the number of ships hauling coal. In 1977 a total of 508 ships loaded coal; by 1982 the number had risen to 911. Please note that in 1977 only 14.5-million tons of coal were loaded into 508 ships or 28,543 tons per ship. By 1982 when 53.0-million tons of coal were shipped, 911 ships were used with an average load of 58,178 tons per ship. This points out that the size of the average load of coal has increased. The average load is still less than one half of the maximum reported load at the N & W Lamberts Point Facility. It is also less than one-third of the load potential of the largest vessel that can be handled by port facilities. I have heard a lot of discussion over the last 10 to 15 years about the maximum load, the optimum load, etc., that can be expected in the future and when it will be loaded. The answer to such discussion can only be given in terms of the depth of water available for navigation.

#### Dredging Needs

A part of my assigned task is to present arguments for dredging selected areas in Hampton Roads. I can do that intelligently only if I know what you want to do or accomplish in or through Hampton Roads. If you want to build only canoes, rowboats, or rafts adjacent to Hampton Roads, or, if you only want to export such coal as you can transport in a canoe, rowboat or raft; and if you are sure that neither Virginia or the United States need the goods arriving on, or the proceeds from the goods leaving on, the 3,000 plus vessels per year that move in and out of Hampton Roads, then, and only then, can we say that we do not need to do some dredging. If you tell me that you want the shipyards to operate, the coal terminals to load and ship coal, and the terminals to ship and receive a multitude of goods, then, yes, we do need to continue to dredge.

Maintenance Dredging.--I will use the dredging I am most familiar with, that at Newport News Shipbuilding, to illustrate why we need to dredge and the impact of

that dredging. In general the design water-depth at these facilities is 35 feet. A few exceptions are 45 feet at Pier 2 south, 40 feet at Shipway 11, and 40 feet at the outfitting berths. A navigation channel outboard of the shipyard varies from 50-plus feet at the south end to approximately 34 feet at the north end. The average annual rate of siltation is approximately 0.8 foot on flat areas outside the channel. Because piers are perpendicular to the river and water is shallower under the piers than in the berth area alongside the piers, the berth areas tend to collect silt at a higher rate. Prevailing southwest or northwest winds, especially during storms, contribute to the buildup of silt in front of the shipyard. Severe storms have deposited one-and-one-half to two feet of silt in a matter of days.

Maintenance dredging quantities have averaged approximately 200,000 cubic yards per year over the last 10 years. Because the facilities have been enlarged, the average volume removed annually will increase. Our present permit for maintenance dredging allows removal of 250,000 cubic yards annually.

New Dredging--New dredging--or dredging to depths deeper than existing bottoms--is determined by changing uses of existing facilities or construction of new facilities. For instance, two years ago we completed and put into operation a new submarine overhaul dry dock which required dredging an access channel to connect it to the navigation channel. Approximately 70,000 cubic yards were moved from that project. Now it must be maintained in navigable condition.

Reasons for Dredging--Siltation decreases the water depth. Vessels have minimum depth requirements depending on the design of the vessel and the load conditions of the vessel. Because of possible structural damage and the possibility of fouling water intakes, vessels must have water of adequate depth. If a given berth is allowed to continue to silt in, that berth will eventually become useless for practical purposes.

#### Environmental Impact of Dredging

The environmental impact of dredging at Newport News Shipbuilding and Dry Dock Company is considered to be minimal, for a number of reasons:

1. Width of water body--five miles wide.
2. Method of dredging--clam shell bucket with material loaded directly into hopper scows.
3. Area affected by turbidity from disturbed material is very small.
4. No prime shell fish areas are located within several hundred yards of dredging areas.
5. We make every attempt to schedule dredging so that the dredge digs efficiently and with minimum creation of turbidity per cubic yard removed.
6. The North-yard expansion project was configured to leave clam-producing areas virtually undisturbed.

Permits and Permit Conditions

Dredging requires permits and certifications from a number of agencies including:

1. Permit from the Virginia Marine Resources Commission.
2. Water quality certification from the State Water Control Board.
3. Permit from the Corps of Engineers.
4. Kepone clearance from the State Water Control Board.

Corps of Engineers permits and water quality certifications often contain restraints on dredging. Our permits did limit dredging to five and one-half months of the year--from mid-March to June 30 and October 1 to November 30--until last year when the time limits were removed. Those limitations were placed by the Corps at the insistence of state and federal review agencies (the Virginia Institute of Marine Science, the U. S. Department of Interior's Fish and Wildlife Service, and the U. S. Department of Commerce's National Marine Fisheries). However, studies done by Virginia Institute of Marine Science (VIMS) at Hampton Bar during a large scale sand-mining-type operation indicated very little impact on the environment--especially when compared to the impact of a normal storm in the same areas. We believe that dredging as it is practiced at our shipyard facilities has far less impact than did the sand-mining operation.

Some of the restrictions and limitations of the various permits increase our costs and create scheduling problems. However, it is the policy of Newport News Shipbuilding to cooperate with the environmental regulatory agencies and to comply fully with the conditions of the permits they issue. We did request variances with the time limitations in a few instances because of unexpected conditions for which we could not schedule dredging within the allotted times.

In 1974, we contracted with VIMS to do a detailed study during a dredging operation and to follow it up with re-evaluation of the area, including repopulation studies, after the dredging was complete. We did that because we could not find studies made of actual conditions, and we were tired of hearing people, who were supposed to be professionals, try to subvert projects through suppositions. We were tired of hearing the words, "This may happen and that may happen." That study found that the high turbidity area remained small and was much less than visualized by looking at aerial photographs. It also showed that the areas repopulated rapidly and with a higher diversity of population. Total biomass was smaller a year after the dredging than before, but the young crop was healthy and growing. We think the VIMS personnel did an outstanding study. We wish others would read it.

I firmly believe that dredging is not the problem for the environment that some would have us believe. In fact I believe that, properly managed, it can be beneficial. If you do not believe that, I would like to show you a couple of local sites that are teeming with flora and fauna a few years after predictions that dredging would kill the area forever.

A PERSPECTIVE ON THE  
NAVY'S ENVIRONMENTAL MANAGEMENT  
PROGRAM

By Paul R. Rakowski, P.E.\*

The United States Navy is concerned about the impact of its wide-ranging operations on the environment. The Navy uses the Chesapeake Bay and its surrounding air and land. Naval activities are small cities with various industries capable of generating pollutants of many kinds--pollutants that could affect the quality of the Chesapeake Bay.

The Navy is well aware of its responsibilities to protect the environment from adverse effects of contamination caused by its ships, aircraft, and shore facilities. Since the early 1970s, the Chief of Naval Operations (CNO) has mandated a program to eliminate or control pollution. The latest guidance is found in the Environmental Protection and Natural Resources Manual, Chief of Naval Operations Instruction 5090.1 of May 26, 1983. To quote:

The Navy will actively protect and enhance the quality of the environment, through adherence to all applicable regulatory requirements, and by initiating actions to conserve natural resources, protect historical and cultural properties, and prevent or control pollution caused by Navy facilities.

The six regional Engineering Field Divisions (EFDs) of the Naval Facilities Engineering Command, headquartered in Alexandria, Virginia, provide activity technical support for environmental management. Responsibilities include: assessments of environmental conditions at activities through surveys and field visits; expert technical representation for cognizant activities in liaison with federal, state or local environmental regulatory agencies; technical assistance to activities in establishing and maintaining corrective pollution abatement actions, environmental monitoring programs, compliance data collection and analysis, and other actions required for environmental quality.

Since 1970 the Navy's capital expenditure for pollution abatement in the Tidewater, Virginia, area alone has approached \$200 million. This paper will identify and discuss the Navy's environmental programs, dollar expenditures, etc. and their relationship to improving water quality in the lower Chesapeake Bay. Specific areas that will be emphasized include planning and siting of facilities, construction, operations, with examples of atypical measures instituted to protect and improve water quality in the lower Chesapeake Bay.

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### Planning and Siting of Facilities

Environmental Assessment.--There is a basic premise that anything man does has an impact upon the environment, and this is particularly true of organizations engaged in national defense. For obvious reasons, both operations and facilities can have an impact on the environment and, hence, water quality. Thus, they must be evaluated prior to conducting the action. The National Environmental Policy Act of 1969 (NEPA) states:

[To] the fullest extent possible all agencies of the Federal Government shall utilize a systematic interdisciplinary approach which will ensure the integrated use of the natural and social sciences of the environmental design arts in planning and in decision-making which may have an impact on man's environment.

The NEPA process requires the Navy to consider the environmental impact of its proposed actions. In so doing, we must consider a full range of alternatives, which include taking no action, as well as those reasonable alternatives which are beyond our immediate jurisdiction. Thus, decision makers are provided sufficient information on which to base informed judgments.

Each project or program, regardless of scope or method of funding, must include documentation of its effects upon the environment. Obviously, not all proposals require the same level and depth of environmental documentation. Chapter 4, in the Navy instruction cited earlier, describes the Navy's process for environmental documentation. The NEPA obliges the Navy to explore all reasonable sources and avenues for determining the extent of any adverse environmental impacts. If impacts exist, reasonable mitigative actions which would lessen or obviate those impacts are undertaken.

The NEPA process also serves as a vehicle for compliance with other environmental related issues such as endangered species, cultural resources, coastal zone management, floodplains, wetlands and intergovernmental coordination. These will be discussed later in this section. Certain issues, which involve emissions into the atmosphere, point source discharges, storage/handling of hazardous wastes, dredge and fill, etc., require further state/federal permitting actions under the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act, and the Federal Water Pollution Control Act, respectively. These permitting requirements are in addition to the procedural requirements of NEPA.

Typical examples of water quality related projects, siting, operations, etc., requiring preparation of an Environmental Assessment (EA) include:

1. Major training exercises on military property.
2. Dredging projects that increase water depth over previously dredged or natural depths, and/or require new spoil area designations except where the Corps of Engineers indicate no EA is required.
3. Proposed utilization of tidelands and freshwater wetlands.
4. New sanitary landfills.

5. Any activity proposed in a designated or recommended "critical" habitat of an endangered species, except where prior negotiations with the Fish and Wildlife Service/National Marine Fisheries indicate no EA is required for the purposes of continued operations and compliance with the Endangered Species Act.
6. Closure or limitation of access to any areas that were open previously to public use, such as roads or recreational areas.
7. Construction or any other action affecting an EPA designated aquifer or recharge zone as specified in the Safe Drinking Water Act.

Other Legislation and Administrative Impacts.--During the NEPA documentation process, certain other issues of legislative origin are normally considered inherent. These issues, some of which have stipulated procedural coordination requirements above those of NEPA, are outlined below:

1. Endangered Species Act of 1973: Proposed actions must not jeopardize the continued existence of endangered or threatened species or modify critical habitat of same. If endangered species are present in the area of the proposed action, a biological assessment is required and may be incorporated into the environmental documentation. If an action may affect an endangered species, consultation with the U. S. Fish and Wildlife Service is required.
2. Coastal Zone Management Act (1972): Although federally owned lands are excluded from the Coastal Zone Act, Navy policy requires that actions be consistent with the Coastal Zone Management Plan of the particular state to the "maximum extent practicable." Whenever Navy actions have a "spillover" impact into the coastal zone, it is necessary that a consistency determination be submitted to the coastal zone management officer of the appropriate state. Consistency determinations are sometimes required to satisfy the joint permitting process on dredging projects, and such determination could be similarly required on other actions requiring state or joint state/federal permits.
3. Executive Order 11988: Flood Plain Management. Federal agencies are required to avoid construction in flood plains whenever practical alternatives exist. Considerable amounts of Navy-owned land lie within flood plains, hence this is often addressed in Navy environmental documentation.
4. Executive Order 11998: Protection of Wetlands. Federal agencies must not construct in wetlands unless it can be shown that no practical alternative exists and that the proposal contains all practical measures to minimize harm to wetlands including mitigation. A Corps of Engineers permit for filling in wetlands is required under section 404 of the Clean Water Act.
5. Executive Order 12372: Intergovernmental Review of Federal Programs (formerly the Intergovernmental Cooperation Act; OMB Circular A-95). This order provides for the coordination of appropriate Department of Defense (DOD) development programs and activities with federal, state

and local agencies, and encourages these agencies to coordinate programs and activities with the DOD. The state and regional clearinghouses are frequently utilized to assist in the scoping process for environmental assessments. This allows environmental documents to be tailored to specific concerns and eliminates the costly effort required to analyze a myriad of issues which, ultimately, have no substantive impact. Clearinghouses are also used for the dissemination of environmental documents to the public when required. Local/state clearinghouses that we routinely coordinate with are: the Southeastern Virginia Planning District Commission (SVPDC), the Peninsula Planning District Commission (PPDC), and the state clearinghouse of Virginia

Summary.--Every action or proposed action by the Navy has the potential, even if remote, to affect the environment, especially water quality, under a given set of circumstances. The Navy's program to implement the NEPA regulations covers the myriad of decisions being made on a daily basis throughout the Navy. Consideration of environmental factors at the earliest practical stage in the planning/siting process as required by NEPA is a way of life for managers in the Navy. This first phase of the Navy's environmental program complements other requirements needed in the decisionmaking process such as: mission, function, technology, cost-effectiveness, etc.

#### Design and Construction of Facilities

The Atlantic Division, Naval Facilities Engineering Command is charged with the design and construction management at over 200 Naval activities in one-third of the world. The command will oversee the design and construction of nearly \$380 million of projects during the next fiscal year. Of this, \$151 million will be spent in the Virginia's Tidewater area. An important task contributing to improvement in water quality in the Chesapeake Bay is insuring that this construction is designed to meet all federal and state environmental standards.

Wastewater Discharges.--The Environmental Quality Branch at the Atlantic Division is involved in the planning, review, design, and construction of these facilities. Those projects with significant water quality impacts, such as new wastewater treatment systems, are carefully planned and built to meet or exceed environmental standards. Wastewater from operations such as aircraft washing, metal finishing facilities, paint stripping, coal piles, etc., is collected, treated to environmental standards and discharged either to the receiving waters or to the sanitary sewer system. Appropriate environmental permits are obtained to insure that quality of these discharges meets or exceeds State of Virginia standards or standards imposed either by the city of Portsmouth or the Hampton Roads Sanitation District (HRSD). Currently, the Navy manages a secondary domestic wastewater treatment plant at Cheatham Annex and a \$1 million advanced tertiary facility at Northwest.

Industrial wastewater from ship and aircraft overhaul, fire fighting areas, and ship oily waste collection systems is treated in sophisticated treatment facilities constructed over the last 10 years. For example, the \$7 million industrial waste treatment plant at the Naval Air Rework Facility located along Willoughby Bay, treats an average of 120,000 gallons per day (GPD) via chemical destruction processes, neutralization, filtration, and carbon absorption. All this treatment for

removal of heavy metals and organic compounds occurs prior to discharging to HRSD. Oily wastes from ships are collected in barges and transferred to a Naval Supply Center facility at Craney Island. Here they are treated, along with shore-generated oily wastes, to reclaim the oil. This \$5 million oily wastewater treatment plant can treat up to one million gallons per day using equalization, gravity separation, dissolved air flotation, sand filtration, and carbon absorption. Treated water is then discharged into Hampton Roads.

Spill Control.--Other water quality related control facilities are provided during the design phase such as Spill Prevention Control and Countermeasure (SPCC) devices for petroleum products. Typical devices installed include overflow vent alarms, fill pipe containment, above ground tank containment, and fuel level indicators on large tanks. Waste oil collection systems are provided in both production and hobby shops with storage tanks and recycling of waste oils.

No engineered system can control accidents that may occur; therefore, the Navy has an extensive oil spill response capability available at all activities. Oil containment booms, various types of oil spill clean-up equipment including both truck mounted and open water skimmers form the Navy's arsenal for containing and clean-up of accidental oil spills. With the increased emphasis being placed on the control of hazardous substances, existing spill response capabilities are being expanded at Navy activities. To supplement existing efforts, full-time, on-scene operations teams for hazardous substance spills are being formed at the Norfolk Naval Base complex and at the Norfolk Naval Shipyard in Portsmouth, Virginia. These separate forces should be fully trained and operating by 1985.

Ship Generated Wastes.--The most significant step taken to date has been the collection and treatment of ship-generated sewage. Navy vessels have been retrofitted, at an approximate cost of \$100 million, with on-board sewage holding tanks for use while transiting the lower bay (i.e., inside the three-mile limit) and then while in port. An estimated one million gallons per day of ship-generated sewage is being collected and discharged through Navy activity sanitary sewer systems for treatment at the facilities of either HRSD or the city of Portsmouth. Naval ships have been utilizing these \$15 million shoreside collection systems since 1978.

Construction Activities.--Besides the design and construction of facilities related to the direct control of pollutants impacting water quality, all construction contracts contain environmental protection requirements. The contractor, in his environmental control plan, must specify how he intends to control erosion, refuse, demolition debris, damage to plants, and handle the disposal of any oily wastes and hazardous materials such as asbestos and PCBs. For contracts involving the disposal of either industrial residues, such as sandblast grit, or hazardous waste, the contractor is required to provide copies of the disposal permits. The permitted facilities must be approved by the EPA and/or the state prior to removing any material for disposal. While this level of control works, on occasion, Navy contractors are apt to dispose of construction residues improperly. In the two or three incidents that have occurred, our command coordinated with agencies such as the State Water Control Board and the Health Department, to correct such problems. The contractor is directed to remove, clean-up, and dispose of these wastes in the permitted landfill.

Summary.--The Navy in Tidewater has worked over the last years to design and construct a variety of projects directly related to improving water quality in the Chesapeake Bay. Well over 100 projects costing approximately \$100 million have upgraded the Navy's environmental control systems. The Navy has provided funds directly to HRSD/Portsmouth to upgrade their wastewater plants. The Navy cost for these upgrades is anticipated to exceed \$10 million. Oil SPCC upgrades and connection of well over 100 industrial waste sources to treatment systems has been accomplished. Tidewater activities currently have 55 major pieces of ships' waste collection/oil spill cleanup equipment and 29,000 feet of oil spill containment boom, worth approximately \$10 million. As stated earlier, \$100 million was expended on ships to collect over one million gallons per day of sewage from more than 100 vessels. Also, yearly operation/maintenance costs for all these facilities exceed \$10 million. The net results of the above water quality related efforts are:

1. Replacing Navy secondary sewage treatment plants, which were nearing the end of their service lives, with connections to HRSD.
2. Reducing the number of Navy NPDES discharges to a few treated discharges (and non-contract cooling water/steam condensate discharges).
3. Transferring ship sewage ashore from virtually all vessels and most service craft.

The Navy must meet the same standards as any other industrial or private discharger. The Navy follows the same procedures (e.g., submit monthly monitoring reports to the regulatory agencies), and we are inspected by state and federal regulatory agencies. In the past two years, Virginia inspectors have spent several man-weeks on board the various activities inspecting and certifying wastewater collection systems and hazardous waste operations.

### Operation

Pollution Abatement Facilities.--All the expenditures possible alone, and in and of themselves, will not insure that Navy operations do not impact on the bay's water quality. If this were so, we and all bay users would have no need to train and to inspect our day-to-day operations. This is one of the purposes, as stated earlier, of the Atlantic Division's staff of environmental engineers, applied biologists, and technicians. By routine surveys and assessments, they review both the activity's physical plant for environmental compliance and the operator's level of expertise. Recommendations for facilities are also provided which form the bases of the capital construction program outlined earlier. Operator expertise and management systems are reviewed to insure that environmental systems are being operated efficiently and in compliance with permits and standards.

Navy operators of both domestic and industrial wastewater facilities are trained and become certified operators under Virginia regulations. In addition to State-run training courses, Navy operators have attended commercial- and contractor-prepared courses for water and wastewater treatment, hazardous waste management, and oil and hazardous substance spill control and clean-up.

Natural Resources.--The Navy is the owner and caretaker of a considerable amount of land, which can influence nonpoint pollution sources, and numerous buildings. Prior to the implementation of environmental regulations, the Navy had been involved in the proper management and protection of these holdings.

All Navy installations are managed in consonance with the Naval mission assigned to provide for multiple-use management of natural resources to:

- 1) protect, conserve, and manage the watersheds and natural landscapes, the soil, the beneficial forest and timber growth, fish and wildlife, and other renewable resources, as vital elements of an optimum natural resources program,
- 2) utilize and care for natural resources in the combination best serving the present and future needs of the United States and its people, and
- 3) provide for the optimum development of land and water areas and access thereto while maintaining ecological integrity.

Pest and Pesticide Management Programs.--The Department of Defense and the Navy's pest and pesticide management program has been in existence prior to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulations. The programs are run by certified pesticide applicators. Pest control programs are reviewed on an annual basis here in Tidewater by the Atlantic Division's staff of applied biologists.

The Navy's controlling policy for pest management programs has recently been revised in a Chief of Naval Operations Instruction 9250.4 of 28 March 1984. As stated, it is Navy policy to:

- 1) safeguard human health and morale by controlling pests that transmit diseases or annoy personnel;
- 2) maintain real property and prolong the service life of facilities, structures and material by preventing pest attack;
- 3) enhance environmental quality through the protection of desirable plant and animal resources;
- 4) ensure that pesticides are used in a manner which will protect the safety and health of Navy/Marine Corps personnel;
- 5) using the full spectrum of practical control techniques, minimize reliance on chemical pest control procedures through an integrated pest management approach;
- 6) ensure compliance with quarantine matters related to protecting plants, animals, and human health; and
- 7) comply with laws concerning pesticide application, storage, and disposal.

To fulfill these policy guidelines, Navy shore activities in Tidewater are required to have a pest management plan specific to each activity. These plans

document the types of pests to be controlled and control techniques, locations, pesticides to be used, environmentally sensitive areas to be avoided, and health and safety measures to be employed. Daily operations on pest management are recorded and provided monthly to the Atlantic Division for review and comment.

The activities have at least one certified applicator on-board. This certified applicator receives extensive training and refresher training to achieve and maintain this certification. Requirements include high school diploma or equivalent, correspondence course completion, and on-the-job training before being recommended to attend a four-week course at a DOD training center. If the candidate is successful, certification is valid for only three years, at the end of which refresher training and retesting is provided prior to being recertified.

To minimize contamination to Navy lands, only EPA-registered pesticides are used. The types and quantities used are controlled by the Atlantic Division's Staff at the purchase step. All procurements of restricted-use pesticides are approved by our professional entomologists prior to being purchased.

Contract pest control services provided to Navy activities are required to follow the same reporting requirements as the government operations. A trained and certified government inspector oversees the contract operations. The training and certification for government inspectors is similar to that required of applicators. The contract services must also utilize the activities pest management plan as the operating guide for pesticide use.

Hazardous Waste Management.--Most DOD activities, including the Navy, generate hazardous wastes (HW) that must be handled and disposed of in an environmentally acceptable manner. In view of the Navy's extensive involvement in this area, regulatory requirements, the need to protect people from Navy hazardous wastes, and the inherent need for human concern, a formal Navy program for the control of hazardous materials and wastes has been in place since February 1980. Navy personnel at hazardous waste facilities are familiar with the requirements of this program, including their specific role.

In general, the program requires shore activities to develop written management plans and implement programs to segregate, identify, collect, and store HW. Ships are required to identify, document, containerize, and turn over HW to shore activities. The Defense Logistics Agency (DLA), through its defense property disposal system (DPDS), is charged with providing the final disposition service to all DOD components. Disposition can include recycling, reuse, sale, or ultimately, disposal at a permitted HW facility. The primary means of disposal of these wastes is by off-site disposal at out-of-state EPA-approved treatment, storage, and disposal facilities. Hazardous materials which may contribute to this waste stream are bleach, concrete floor cleaners, battery acid, cleaning solutions, paints, paint thinner, metal finishing and plating solutions, drain cleaners, and solvent/degreasing compounds.

The Navy's Public Works Center (PWC), Norfolk, provides a centralized handling, collection, and storage service for Navy activities in the Tidewater area. The PWC identified, packaged, transported, and stored, 485,000 gallons of HW for the Navy in 1983. The storage facility, located on the Commander Naval Base Norfolk property, was an existing hazardous material warehouse upgraded to meet all the storage requirements of the HW regulations.

Thirteen (13) Navy activities in Southeast Virginia notified the Environmental Protection Agency (EPA) of HW activity in August 1980. In November 1980, eleven of these activities submitted HW Part A applications to the EPA. Since this original submittal, five activities were determined to be generators only or small quantity generators. One Navy HW Part B permit has been requested to date for Virginia Navy activities under our cognizance. This was a permit for HW storage at the Norfolk Naval Shipyard, Portsmouth. The completed permit application was submitted to EPA and the Commonwealth of Virginia in November 1983. Additional Part Bs are expected to be called at other activities in the near future. In order to ensure compliance with RCRA storage requirements at local activities, HW storage facility upgrade projects have been initiated at nine activities for approximately \$1.8 million.

Tidewater Navy HW generation during 1982 was approximately one million gallons distributed between various Navy activities in the following ratios:

<u>Activity</u>	<u>Percent of total</u>
Norfolk Naval Shipyard Portsmouth, Va.	60.03
Commander, Naval Base Norfolk, Va.	37.30
Naval Weapons Station Yorktown, Va.	1.04
Fleet Combat Training Center, Atlantic Dam Neck Virginia Beach, Va.	---
Naval Air Station, Oceana Virginia Beach, Va.	0.20
Naval Amphibious Base, Little Creek Norfolk, Va.	1.29
Naval Security Group Activity, Northwest Chesapeake, Va.	0.03
Naval Radio Transmitting Facility Driver Suffolk, Va.	---
Naval Hospital Portsmouth, Va.	0.06
Cheatham Annex Naval Supply Center, Norfolk Williamsburg, Va.	---

The Navy's HW operations have been established to meet the requirements of regulations established by both the EPA and the Commonwealth of Virginia. All the efforts documented above contribute to waste quality improvement. Proper management of HW at permitted facilities clearly identifies the Navy's commitment to prevent improper and illegal disposal in the Chesapeake Bay area.

Past Waste Disposal Site Investigations.--The most newsworthy environmental problem in the country today is the identification and clean-up of past hazardous waste disposal sites. These sites can pose a threat to both human health and the environment. Preventing threats to the environment of Chesapeake Bay water quality is a situation which the Navy has been most concerned with in the last several years.

The Department of the Navy began a comprehensive program in 1980 to control the possible migration of potentially hazardous environmental contamination from disposal sites. The Navy Assessment and Control of Installation Pollutants (NACIP) program was instituted to systematically identify, assess, and control contamination from suspected past hazardous material operations that might possibly pose a threat to human health or the environment.

The NACIP program consists of three separate and distinct phases:

1. Initial Assessment Study (IAS).--Collecting and evaluating evidence that may indicate the existence of pollutants that may have contaminated a site or that might pose a health hazard or an impact to the environment either on or off the installation.
2. Confirmation Study (CS).--Performing field investigations, including detailed physical and analytical monitoring, to confirm or deny the presence of contamination or a health hazard, and to quantify the extent of any problems that might exist.
3. Corrective Measures.--Instituting needed remedial measures to control and mitigate contamination. The conduct and prioritization of phases (2) and (3) is based on the findings of the preceding phase; obviously, negative or insignificant findings result in termination of the NACIP program for the particular site.

The IASs have been completed at seven Tidewater activities with four more in progress at this time. As a result of these efforts 127 various sites have been investigated with 57 recommended for further study. Confirmation study efforts are underway at four of these activities.

To date, approximately \$715,000 has been spent on conducting IASs at these activities. The second phase efforts are projected to cost upwards of \$2 million over the next three years. Since the studies have not been completed, costs for remediation and clean-up, if required, are not available. The Navy can state that to date, no sites have been found that pose an imminent threat to health or the environment.

Solid Waste Management.--The Navy's solid waste program in Tidewater has been a leader in technology and area-wide cooperation. The Navy has only one permitted sanitary landfill in operation at the Naval Air Station, Oceana in Virginia

Beach. Navy activities on the Peninsula area of Hampton Roads contract for off-site disposal of solid waste. Refuse-fired boilers are used to handle solid waste from the Naval Base Norfolk; Naval Amphibious Base, Little Creek; and the Norfolk Naval Shipyard, Portsmouth.

The refuse-fired boiler at the Naval Base Norfolk was the first mass-fired water-wall incinerator constructed in the United States. This facility, on-line since 1967, currently handles about 140 tons of waste per day. The Norfolk Naval Shipyard has been using a mass-fired incinerator since 1976. The current processing rate is 55 to 60 tons per day of solid waste. Both of these plants are used to produce steam for use by the Navy shore facilities and ships. The emphasis is on providing steam to the fleet, so that ships' boilers can be shut down to conserve fuel, to reduce air emissions, and for maintenance.

The Navy is cooperating in the regional trash-to-energy program. The Navy will purchase processed refuse derived fuel (RDF) from the Southeastern Public Service Authority (SPSA) to burn and produce steam and electricity for use at the Norfolk Naval Shipyard. Excess electricity will be sold to Virginia Power.

This effort of regional cooperation will result in improvement of environmental quality through reduced reliance on land-based disposal techniques. In addition to the Navy, the communities of Norfolk, Portsmouth, Chesapeake, Suffolk, Franklin, Southampton County, and Isle of Wight County are participants in the project.

The \$105 million Navy power plant at the Norfolk Naval Shipyard to burn RDF, coal, or a mix of the two fuels is currently under construction. Construction is expected to be completed with the plant and on line by Fall 1986.

The SPSA processing plant is to be located on adjacent Navy property at the shipyard. Following final agreement, it is projected that design and construction would begin about August 1984 with completion about mid-1987.

### Conclusion

The Navy in Tidewater has the potential for impacting the water quality in the lower Chesapeake Bay. As outlined in this paper, the Navy, since the 1970s, has had a specific program to identify and control both actual and possible sources of contamination. Our participation in various water quality studies, such as the 303e efforts on the James River and the York River, and the Hampton Roads Water Quality Agency 208 Study, are indicative of our continuing commitment to improving water quality in the Chesapeake Bay. The Navy, as well as other DOD agencies along the bay, remains committed to minimizing any operational impacts on water quality. As the largest employer in southeast Virginia, the Navy has a vested interest in protecting the bay and will continue to use the bay for our national defense posture and for recreational use by those who make up the Navy in Tidewater.



## THE WISCONSIN NONPOINT SOURCE WATER POLLUTION ABATEMENT PROGRAM

By Bruce J. Baker\*

I am pleased to have the opportunity to present Wisconsin's Nonpoint Source Program. I would like to highlight seven aspects of the program that I believe have application to the development and implementation of nonpoint source programs elsewhere. These seven aspects are: 1) the program's purpose and objectives, 2) the focusing, planning, and implementation to achieve maximum benefits, 3) the program's structure, process, and staffing needs, 4) the implementation process, 5) the state budget support, 6) an interim evaluation of two Wisconsin watershed projects, and 7) some key principles or "tricks of the trade" learned during the first six years of the Wisconsin program.

The Wisconsin Nonpoint Source Water Pollution Abatement Program was created in 1978 by the Wisconsin Legislature. The legislature recognized that many of Wisconsin's significant water resources were not going to be improved or protected through point source controls alone. Thus, it created the nonpoint source program as part of the Wisconsin Fund, which designates funds for nonpoint source controls, municipal waste treatment, solid waste management, and septic system grants. The nonpoint source program is a water quality program and is one component of the state's overall policy towards achieving fishable and swimmable water resources as mandated by federal and state laws. Much of the initial program development for the nonpoint source program was accomplished through the areawide planning process. Special grants were used to develop much of the technical basis for the program.

### Purpose and Definition

The purpose of Wisconsin's nonpoint source program is to improve and protect the quality of water in Wisconsin's lakes and streams and in groundwater impaired by nonpoint sources of pollution. Pollution from nonpoint sources is carried to lakes and streams by runoff from rainfall and snowmelt. This is in contrast to point sources of pollution which are concentrated discharges of wastewater from distinct sites. Both urban and rural areas contribute to nonpoint source pollution, causing more chronic water quality impacts than point source discharges and requiring a different management scheme than point sources to achieve water quality objectives. In Wisconsin, the major categories of nonpoint source pollution are: a) mismanagement of animal wastes, b) eroding croplands, c) over-grazed woodlands, d) eroding construction sites, and e) increased, mismanaged stormwater runoff from urban and urbanizing areas.

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Implementation of the Program

Wisconsin's nonpoint source program is implemented on a priority watershed approach. (These critical watersheds average about 150 square miles in size.) The watershed approach to implementation allows all categories of nonpoint sources within critical areas of a watershed to be identified and addressed through the installation of corrective land management practices. This approach also allows sources and areas that are not contributing to water quality impairment to be identified and excluded from the project area. The critical categories and locations of nonpoint source pollutants that are contributing to water quality impairment are identified through a detailed watershed inventory.

Examples of the types of pollutant loadings that can be determined from the detailed watershed inventories are shown in table 1. These data are based on recent inventories conducted in two priority watershed projects.

Table 1.--Pollutant loading summaries from two priority-watershed inventories

Watershed	<u>Animal waste phosphorus</u>		<u>Crop and soil loss</u>	
	Percentage of farms contributing	Percentage of phosphorus contributed	Percentage of farms contributing	Percentage of soil loss contributed
	----- Percent -----			
Turtle Creek	30	64	45	80
Kewaunee River	27	59	31	66

Implementing the nonpoint source program through a priority watershed approach also has these advantages: 1) allows available financial and technical resources to be concentrated in those critical watersheds where maximum water quality benefits will result from the investment made, 2) provides an effective framework for project implementation, and 3) allows activities to be targeted into critical areas relative to achieving a defined water quality objective.

Wisconsin's nonpoint source program is designed to make cost-sharing funds available to identified critical landowners and municipalities for the installation of approved land management practices (or best management practices (BMPs)) which will control the nonpoint sources of pollution. Landowner and municipality participation in the program is voluntary.

Funds are also provided through the program to assist local agencies to perform the watershed planning, project management, technical assistance, and educational activities needed to carry out a watershed project.

### Administrative Structure

The administrative framework of the nonpoint source program is set up to provide for local implementation of a watershed project under state-level administration and coordination. The framework is designed to maximize local agency contact with individual landowners and is based as much as possible on existing agencies and institutions.

At the state level, the Wisconsin Department of Natural Resources (WDNR) provides program administration, including selecting priority watershed projects, assisting with the preparation of watershed plans, and disbursing the cost-sharing and local assistance dollars necessary to implement the watershed project activities.

In Wisconsin, the University of Wisconsin Extension System (UWEX) is drawn on to provide education and information assistance both at the state level and through local resource agents.

At the local level, local units of government--that is, the county boards through their land conservation committees, along with municipalities--help identify project needs, develop the actual cost-share agreements with landowners and design and install the needed BMPs. They are also responsible for recordkeeping and are accountable to the state for program implementation. (Beginning in 1981 in Wisconsin, the land conservation committees of the county boards were given the responsibilities previously delegated to the Soil and Water Conservation Districts.)

Federal agency assistance for the program is provided by the Environmental Protection Agency and the U. S. Department of Agriculture through the Soil Conservation Service and the Agricultural Stabilization and Conservation Service.

This program administrative structure has the following advantages:

- 1) It allows for sufficient involvement and guidance by the state water quality agency to assure statewide water quality goals will be achieved and that coordination exists between other water quality and resource management agencies.
- 2) It allows for a direct link between the local implementing agencies and the state water quality agency and requires the local-level implementing agencies to be more directly responsible to the state-level government rather than federal-level agricultural agencies.
- 3) It allows project implementation responsibilities to be carried out by those local resources management agencies, such as the SCS, ASCS, and UWEX, that already have daily involvement with landowners, and the county boards, and that are currently responsible for designing and installing land management practices.
- 4) It creates local "ownership" of the watershed project, a condition that is important for the project's successful implementation.

### Ongoing Priority Watershed Projects

Since 1978, the nonpoint source program has initiated the implementation of 26 priority watershed projects as well as 28 smaller local priority projects, as shown in figure 1. Five priority watersheds were selected in 1979, four in 1980, two in 1981, two in 1982, four in 1983, and nine in 1984. The names, counties, year selected, area, primary water quality objectives and major nonpoint sources for each of the projects is given in table 2.

These watershed projects all fall within the area of Wisconsin where valuable water resources are most significantly affected by nonpoint sources. The critical area of the state forms a "U" shaped pattern along the west, south, and east portions of the state, as shown in figure 1. This "critical U" includes both watersheds with streams and lakes that need rehabilitating and watersheds that need protection of existing good water-quality conditions. It contains about 130 out of 330 total watersheds in the state, 120 deep high quality recreational inland lakes, the nearshore waters of Lake Michigan, almost one-half of Wisconsin's class I and II trout streams (a total of 4,000 miles), and many small-mouth bass streams (a total 3,500 miles), as well as many streams that have become degraded over the years. The area has the greatest potential nonpoint source pollution problem within the state because it includes the majority of the urban areas, the greatest acreage of row crops, the most erodible soils, the steepest slopes, and much (but not all) of the livestock found in the state.

### Priority Watershed Project Selection

Priority watershed projects are selected based on the following six criteria:

- 1) The severity of the water quality problems in the watershed.
- 2) The importance of controlling land uses to achieve water quality standards.
- 3) The landowners' willingness to participate in the program and install BMPs.
- 4) The willingness and capability of local agencies to carry out the program.
- 5) The willingness and capability of local agencies to control other sources of pollution such as adopting construction erosion and runoff control ordinances or controlling problem septic systems.
- 6) The potential public use and benefit of the project.

The watersheds are selected through the following four-step process. First, the most critical 25 percent of the state's 330 watersheds are identified using a numerical ranking based on a technical evaluation of water quality and pollution potential from urban and rural land uses. This process included a provision for additional "wildcard" watersheds that were not included in the initial list. "Wildcards" can be nominated either by the public or by agency personnel. Second, 10 regional review committees are assigned the task of reviewing the watersheds in their designated region and narrowing the initial screening down to

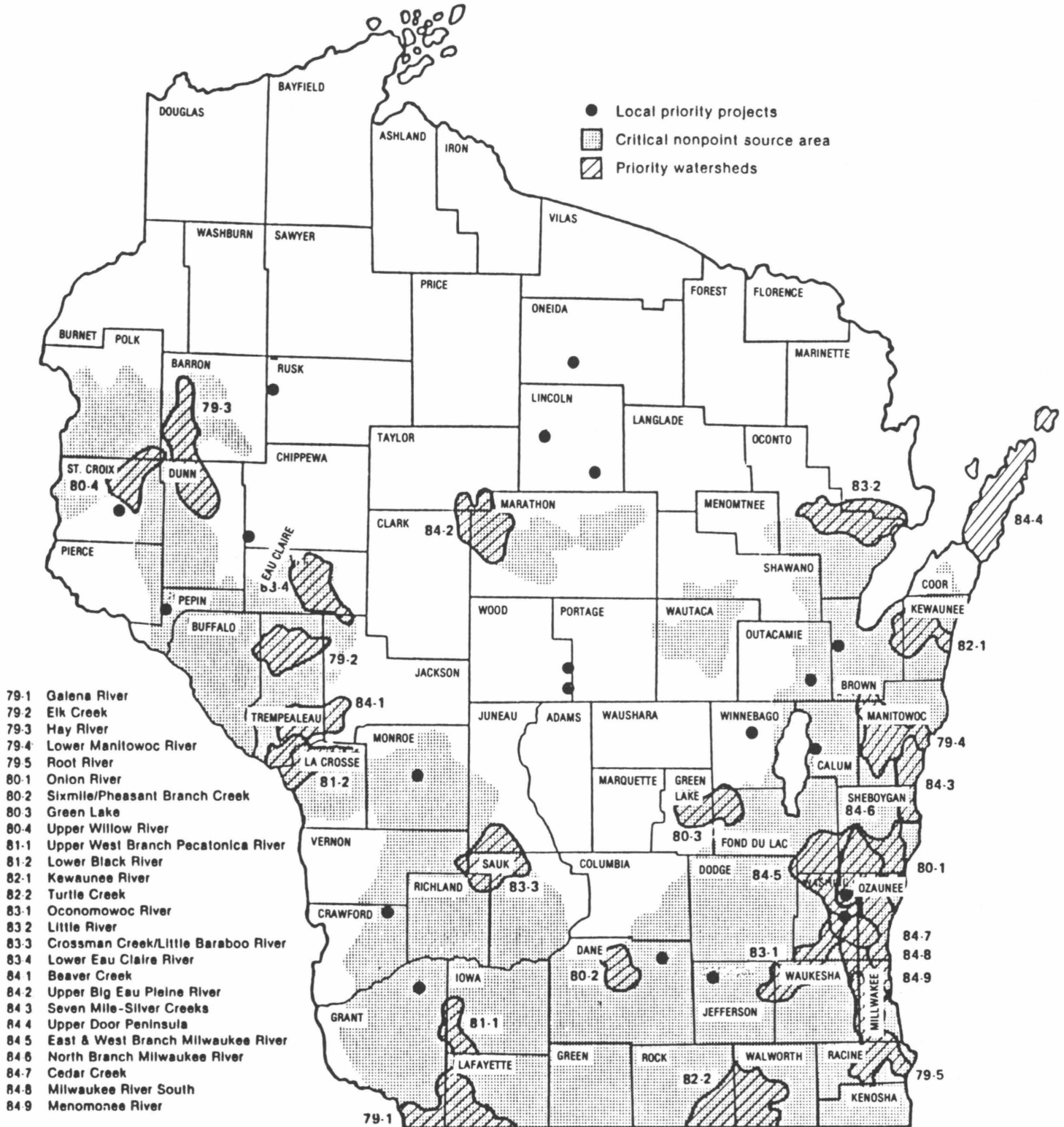


FIGURE 1.  
 Location of the Wisconsin Nonpoint Source Control Program Priority Watershed  
 Projects selected through 1984.

TABLE 2.--CURRENT PRIORITY WATERSHED PROJECTS IN WISCONSIN

Map Number	Project	County(ies)	Year Project Selected	Area (square miles)	Primary Water Quality Objective*	Major Nonpoint Sources**
79-1	Galena River	Grant, Lafayette	1979	242	2	a,c
79-2	Elk Creek	Trempealeau	1979	113	3	a,d
79-3	Hay River	Barron, Dunn	1979	276	3,5	a,d
79-4	Lower Manitowoc River	Manitowoc, Brown	1979	160	1	b
79-5	Root River	Racine, Milwaukee, Waukesha	1979	197	1	c,d,e
80-1	Onion River	Sheboygan, Ozaukee	1980	111	1	b,c
80-2	Sixmile-Pheasant Branch Creek	Dane	1980	118	6	c,e
80-3	Green Lake	Green Lake, Fond du Lac	1980	98	7	a,d
80-4	Upper Willow River	Polk, St. Croix	1980	177	6	c,d
81-1	Upper W. Br. Pecatonica River	Iowa, Lafayette	1981	77	2	a,d
81-2	Lower Black River	La Crosse, Trempealeau	1981	164	2,3	a,c,d
82-1	Kewaunee River	Kewaunee, Brown	1982	135	1,3	b
82-2	Turtle Creek	Walworth, Rock	1982	299	2	c,d
83-1	Oconomowoc River	Waukesha, Washington,	1983	131	7	a,e
83-2	Little River	Oconto	1983	216	1,4	a,d
83-3	Crossman Creed/Little Baraboo River	Sauk, Juneau, Richland	1983	218	2,3	a,c
83-4	Lower Eau Claire River	Eau Claire	1983	117	3	a,d
84-1	Beaver Creek	Trempealeau, Jackson	1984	155	3	a,d
84-2	Upper Big Eau Pleine River	Marathon, Taylor, Clark	1984	230	6	b
84-3	Seven Mile-Silver Creeks	Manitowoc, Sheboygan	1984	112	1,6	b
84-4	Upper Door Peninsula	Door	1984	324	8	a,b
84-5	East & West Branch Milwaukee River	Fond du Lac, Washington, Sheboygan, Dodge	1984	264	1,2	a,c
84-6	North Branch Milwaukee River	Sheboygan, Washington, Ozaukee	1984	147	1,3	a
84-7	Cedar Creek	Washington, Ozaukee	1984	127	1	c,e
84-8	Milwaukee River South	Ozaukee, Milwaukee	1984	156	1	e,f
84-9	Menomonee River	Milwaukee, Waukesha, Ozaukee, Washington	1984	136	1	e,f

\*1. Protect nearshore waters of Lake Michigan  
 2. Rehabilitate warmwater fishery  
 3. Rehabilitate coldwater fishery  
 4. Protect warmwater fishery  
 5. Protect coldwater fishery  
 6. Rehabilitate inland lake  
 7. Protect inland lake  
 8. Rehabilitate groundwater

\*\*a. Barnyard runoff  
 b. Manure spread on cropland  
 c. Cropland erosion  
 d. Streambank erosion  
 e. Construction site erosion  
 f. Urban runoff

three watersheds per region. Third, the State Nonpoint Source Coordinating Committee (SNPSCC) then reviews the approximately 30 watersheds and recommends a "pool" of 15 to 20 watersheds to WDNR. The SNPSCC is comprised of federal, state, local, rural, urban, and interest group representatives. Fourth, the WDNR selects about four watersheds per year from the "pool" in which to initiate watershed projects. The overall goal of the program is to be able to initiate eight new watershed projects each year until the 130 critical watersheds have been addressed. The increasing interest and legislative support for the nonpoint source program has allowed an increasing number of watersheds to be selected each year since 1978.

### Project Implementation

Within the context of systems planning (that is, "208" planning), watershed project implementation planning takes place as a complement to facilities planning (that is, "201" planning). The watershed project implementation process follows an eight or nine year schedule once the watershed has been selected. The process includes:

- 1) Approximately one year of watershed inventory and plan preparation to:
  - identify the water quality problems, objectives, nonpoint sources, and needed BMPs;
  - identify the agency roles during project implementation;
  - identify technical assistance, financial assistance, educational needs, and estimate costs; and
  - identify the landowner contact schedule.
- 2) A three-year landowner sign-up period following approval of the watershed plan during which landowners and municipalities can sign up for cost-sharing funds to install BMPs.
- 3) A five-year installation period following the sign-up period, by the end of which all BMPs included on cost-share agreements must be designed and installed.

The status of the priority watershed projects as of mid-1984 included four projects that have completed the landowner sign-up period, nine projects in the landowner sign-up period, and 13 projects in various stages of the watershed planning phase.

### Appropriations

The nonpoint source program is supported by state funds that fall into three categories:

- 1) Cost-share dollars made available to landowners and municipalities for installing BMPs.
- 2) Local assistance aids to local implementing agencies for technical assistance, education and information programs, and financial and project management.
- 3) Administrative/planning funds for state-level administration.

The current priority watershed projects range from \$600,000 to \$2,500,000 in cost-share needs, with an average of \$1,500,000 per watershed used for estimating budget needs. As of fiscal year 1985, a total of \$19,068,800 in cost-sharing and \$2,097,300 in local assistance aids have been appropriated at the state level to support the nonpoint source program.

The division of cost-share dollars among categories of nonpoint source pollutants to date in the priority watersheds, is as follows: 42 percent for animal waste management, 27 percent for cropland management, 16 percent for streambank management, and 15 percent for other nonpoint source management, primarily critical areas.

Implementing nonpoint source projects in all the critical watersheds, 130 in the state, will require approximately \$300,000,000 (\$225,000,000 in cost-share dollars and \$75,000,000 in local assistance aids). This contrasts sharply with the estimated \$1.44 billion of state funds needed for point source controls. So, including funds already spent, the total nonpoint source need for the state is equivalent to 16 percent of the total point source control costs (including grant dollars only). This indicates water quality improvements through nonpoint source controls are a relative bargain. The WDNR has developed a 25-year strategy for planning and implementing priority watershed projects to accomplish these nonpoint source controls.

#### Interim Evaluation: Accomplishment Indicators

In the spring of 1984, an interim evaluation of two priority-watershed projects, the Elk Creek watershed and the Hay River watershed, were conducted by the WDNR. As shown in figure 1, the Elk Creek watershed is located in west central Wisconsin in Trempealeau County, and the Hay River watershed is located in northwest Wisconsin in Barron and Dunn Counties. These two are the first priority watersheds to complete their landowner sign-up phase. Both watersheds have a remaining five years to design and install the practices included on the cost-share agreements. Because the extent of BMPs to be installed through the nonpoint source program can now be obtained from the cost-share agreements, it is possible to make estimates of where water quality improvements will occur after all the BMPs are installed.

The major water quality objectives for the Elk Creek watershed are to 1) reduce very high fecal coliform levels, 2) improve the degraded trout habitat, and 3) reduce the sediment load to Bugle Lake. For the Hay River watershed, the major water quality objectives include 1) protecting both the naturally reproducing and stocked trout streams, 2) preventing further degradation of a number of large deep lakes, and 3) improving water quality in the warm-water fishery streams.

Estimated reductions in the critical nonpoint source pollutant loadings to a watershed's lakes and streams, because of the installation of BMPs, can serve to indicate the extent and location of the expected water quality improvements that will occur once all the BMPs are installed. These "accomplishment indicators" are specific to the water quality objectives for a given project. The accomplishment indicators for the Elk Creek and Hay River priority watersheds are shown in table 3.

Table 3.--Accomplishment indicators for two watersheds: Elk Creek and Hay River

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<u>Watershed</u>	<u>Percentage under cost-share agreements of</u>	
	<u>Animal units to control barnyard runoff</u>	<u>Eroding stream-banks to control streambank erosion</u>
	----- Percent -----	
Elk Creek*	70	82
Hay River*	67	44

---

\*For the watershed as a whole, percentages vary for individual tributary areas within each watershed.

Mapping the locations of all categories of BMPs installed under the watershed projects provides a visual summary of the expected watershed accomplishments as well as illustrates the comprehensiveness of nonpoint source controls achieved under the nonpoint source program. This comprehensive "systems" approach can also be illustrated by the before and after conditions of a barnyard and streambank of a landowner located along Vance Creek, a trout stream in the Hay River watershed. Significant aesthetic and water quality improvements resulted within three years after the practices, which included streambank fencing and barnyard runoff controls, were installed.

The conclusions from the interim evaluation of the Elk Creek water and Hay River watershed projects follow.

- 1) Both projects will substantially meet their project objectives when all the BMPs are installed.
- 2) Achievement of accomplishment indicators is the only means for measuring the degree to which a watershed project has met its objectives.
- 3) The watershed project approach is an effective means for achieving nonpoint source pollutant reductions and subsequent water quality goals.

Key Principles of a Nonpoint Source Program

In conclusion, based on our experience to date with the Wisconsin Nonpoint Source Water Pollution Abatement Program, we feel the following "tricks of our trade" should be considered when developing an effective nonpoint source program:

- 1) The program should be comprehensive and address all categories of nonpoint source pollutants within a watershed. This includes control of all critical nonpoint sources on an individual landowner's property.
- 2) The watershed inventory prior to implementing a nonpoint source project should be of sufficient detail to identify critical source areas for each category of nonpoint source pollutant, such as detailed modelling of each barnyard runoff situation.
- 3) If the program is voluntary, adequate levels of cost-share and technical assistance and education activities are needed to encourage sufficient participation levels to achieve water quality goals.
- 4) Because not all critical landowners in a watershed will likely participate in a voluntary program, a back-up regulatory program may need to be considered over time.
- 5) There should be a direct link between the local implementing agency and the state's water quality agency.
- 6) Local agencies that are responsible for implementation need to have staff who are technically capable and skilled in project management.
- 7) Inter-agency coordination must be developed in multi-county and multi-municipality projects.
- 8) Methods for encouraging greater participation by landowners in several land-use categories, for example, producers of cash grain in urban fringe areas, should be developed.
- 9) Potential federal legislation may at some point require that states develop effective nonpoint source programs in order to participate in a national nonpoint source program.

And, finally, since valuable water resources will continue to be lost, further delay in implementing nonpoint source programs should be minimized.

## INTERSTATE AND FEDERAL-STATE INSTITUTIONS FOR MANAGING THE CHESAPEAKE BAY

By Margaret R. Johnston\*

While several interstate entities have existed in the Chesapeake Bay region for many years, the states and the federal government have only recently formed government institutions whose primary purpose was to focus attention on the Chesapeake Bay. Two institutions, the Chesapeake Bay Commission(1\*\*\*) and the Bi-State Working Committee(2), were formed in 1980 and 1979, respectively, to better focus the efforts of Maryland and Virginia on the bay. These additions to previously existing interstate river basin commissions created an intergovernmental management network for the Chesapeake Bay(3). Yet, the discussion of whether or not government in the Chesapeake Bay region was sufficiently organized--sufficiently to control man's activities in order to preserve the resources of the Bay--hardly abated after 1980. Indeed, this topic was one of the primary subjects of the ongoing Chesapeake Bay Program conducted by the Environmental Protection Agency(4). Subsequently, the Chesapeake Executive Council was formed as a result of the Chesapeake Bay Conference of 1983(5). The Council was proposed to correct perceived gaps in the management network by involving the federal Environmental Protection Agency, the Commonwealth of Pennsylvania, and the District of Columbia, as well as Maryland and Virginia. For all intents and purposes, the Council replaces the Bi-State Working Committee (which has been allowed to become inactive) as the means of coordinating executive action on the bay. Also as a result of the 1983 conference, the commission, which deals with legislative initiatives for the bay, has begun discussions with Pennsylvania counterparts concerning expanded membership(6).

### The 10 Interstate Institutions

If one considers the entire "Chesapeake Bay System" to include the entire drainage basin and the migratory fish that use it, then there are 10 interstate institutions that are responsible for coordinating some aspect of government activity relating to the resources of the bay. These institutions are listed and characterized in table 1. While no one institution can claim the role of the manager of the bay, with the Chesapeake Bay Commission and the Chesapeake Executive Council serving as a core, these institutions together form a coordinative network with potential for interstate action on nearly any Chesapeake Bay resource management issue which may arise. Examination of table 1 leads to some general statements about the institutions which make up the network:

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\*\*Underscored numbers in parentheses refer to literature cited as references.

Table 1.--Summary of Interstate Institutions in the Chesapeake Bay Region

<u>Entity</u>	<u>Enabling Instrument</u>	<u>Membership</u>	<u>Issues</u>	<u>Functions</u>	<u>Geographic Scope</u>
Chesapeake Bay Commission	Acts of the Md. & Va. Gen. Assemblies, 1980	5 legislators, 1 governor's designee, and 1 citizen from each state	All shared resources of the bay	Assist legislatures, make policy recommendations to a state	Chesapeake Bay tidal waters and dependent resources
Chesapeake Executive Council	Chesapeake Bay Agreement of 1983	2 cabinet secretaries each from Md., Va., Pa., D.C.; Administrator, Region III, EPA	Water quality and habitat for bay species	Coordinate development of plans for improvement of the bay	Chesapeake Bay drainage system in Md., Va., Pa. and D.C.
Interstate Commission on the Potomac River Basin	Potomac River Conservancy District Compact of 1940	3 members each from Md., Va., Pa., W.Va., D.C.; and the federal government	Water pollution, Water supply, water	Coordination of research, technical assistance, planning	Drainage basin of the Potomac River
Susquehanna River Basin Commission	Susquehanna River Basin Compact of 1970	Governors or alternates from Md., Pa., N.Y., and 1 federal member	water supply, use, and quality	Regulation, operation of facilities, research, planning, technical assistance	Susquehanna River watershed
Chesapeake Research Consortium	Incorporation 1972	4 research institutions	Research and education	Coordinated response to research needs	Chesapeake Bay region
Chesapeake Bay Research Coordination Board	Chesapeake Bay Research Coordination Act of 1980	7 federal members, 4 Md. members, 4 Va. members	Federally conducted & supported research	Coordination of federal research efforts	Chesapeake Bay and adjacent resources
Bi-State Working Committee for Chesapeake Bay & Coastal Areas	Governors' Agreement 1979	7 executive agency heads each from Md. and Va.	All shared resources of the bay	Improve day-to-day administrative coordination	Tidal areas of Md. and Va.
Potomac River Fisheries Commission	Potomac River Compact of 1958	3 members each from Md. and Va.	Fisheries	Regulate commercial harvest, replenish oyster bars, research and conservation	Tidal area of Potomac River
Mid-Atlantic Fishery Management Council	Fisheries Conservation and Management Act of 1976	3 members each from each of 6 mid-Atlantic states and NMFS	Fisheries	Develop fisheries management plans, regulate level of foreign fishing	Fishery conservation zone, 3 to 200 miles off shore
Atlantic States Marine Fisheries Commission	Atlantic States Marine Fisheries Compact	3 members each from each of the 15 Atlantic States	Fisheries	Develop fisheries plans, propose laws and regulations	State tidal waters from Maine to Florida

- (1) Only two institutions deal with the bay as a unit. One, the Chesapeake Bay Commission, deals mainly with problems requiring legislative solutions, while the other, the Chesapeake Executive Council, coordinates executive agency activities. The council is broader in geographic scope, but limited to water quality and habitat protection in focus. The commission is not limited in the issues it deals with, but is geographically limited to Maryland and Virginia.
- (2) Two river basin compacts(7,8) are in effect for the two most important tributaries of the bay. The two resulting commissions vary widely in authority, but are similar in their abilities to coordinate, study, and plan for the water resources of their subject basins. This leaves several important drainage areas without any government entity to focus special attention on them, including the small tributaries making up what is known as the West Chesapeake Basin (the Gunpowder, Patapsco, Magothy, Severn, West, and Rhode Rivers in Maryland), the York, Rappahannock, and James Rivers in Virginia, and the rivers of the Eastern Shore.
- (3) Two institutions deal with research coordination. One, the Chesapeake Bay Consortium(9), is an attempt to respond in a coordinated manner to the multidisciplinary needs of government management of natural resources. While it provides an important resource to the governments in the regions, and has played a lead role in identifying priority research needs, it does not have any role in directing or coordinating the research efforts of government agencies. The Chesapeake Bay Research Coordination Board(10) was designed to play that role. The board has never been formally constituted, nor funded, and although National Oceanic and Atmospheric Administration (NOAA) has formed an ad hoc coordinating committee among federal agencies to coordinate research activities, it has not been active.
- (4) Three interstate institutions deal with fisheries management, but none of them focus on Chesapeake Bay as one entity. The Potomac River Fisheries Commission(11) is narrowly focused to regulate fishing activity on the Potomac River. The other two -- the Mid-Atlantic Fishery Management Council(12) and the Atlantic States Marine Fisheries Commission(13)--are much more broadly focused. The council, in fact, deals with an area totally exclusive of the bay. Both, however, develop plans for species of fish important to commerce or recreation in the bay.

Most people, when confronted with this vast array, react with bewildered dismay. "Who coordinates the coordinators?", they ask. Much effort has, in fact, gone into the task of trying to define an ideal organization which would somehow govern, or at least keep tabs on, all important activities in the entire Chesapeake drainage basin(14). I will argue that the existing array of institutions does, in fact, serve as a network that can oversee the revitalization of bay resources. Further, rather than try to consolidate these groups, future efforts at improving the coordination of bay affairs should involve expanding the network to include local governments in a meaningful way.

Efforts to define a single entity to coordinate all bay activities have largely proven to be futile. If it is suggested that such an organization be given true regulatory authority, it is viewed with distrust and suspicion for fear it will usurp traditional authorities of state government. Alternately if the institutions were merely to coordinate all the existing actors, it would have to be so large as to be unwieldy; consensus would prove difficult to achieve. Interstate institutions also seldom make use of all authorities granted to them or deal with the full range of issues that they are empowered to look at. For example, the Susquehanna River Basin Commission was given very broad powers including acquisition of land and facilities, allocation of water, and regulation of water withdrawals and diversions. This commission has, however, played more the role of a planning and technical assistance agency than a regulator. There is also the Atlantic States Marine Fisheries Commission which has been empowered to develop fisheries management plans since its inception in 1940. However, the first plan developed by this commission was published in 1978. Most such interstate organizations, thus, tend to focus their activities more narrowly than their authorizing legislation or compact would suggest that they should.

An interstate institution charged with overseeing all Chesapeake Bay affairs would necessarily focus on the few issues that it perceived as most important, leaving others neglected. A broad array of institutions, however, allows more of the important issues to be covered.

Goetze, et al.(15), suggests that when problems are large and complex, such as those of the Chesapeake Bay, they are better dealt with by a multiplicity of institutions than by a single entity. This is true partly because a healthy competition will make each more effective and lead to a variety of problem solutions and partly because each entity will be able to focus on and develop appropriate expertise in a given role.

None of the interstate institutions analyzed here operate in a vacuum. Not only are they aware of the existence of the other institutions, they nearly all have overlapping membership. Different combinations of the same large group of individuals, thus, gather under the auspices of different interstate institutions to work on solutions to separate, but highly interrelated problems. This can be more clearly seen in figure 1 and figure 2 which show how the membership of these institutions overlap to form a network. What the figures cannot show, because they are necessarily generalizations, is that often the same individual is a state or federal agency's representative to several interstate institutions.

Thus, while it may offend those who desire a simple and neat approach, we may in fact have a system of interstate relationships for the bay that is close to optimal. This does not mean that no adjustments could be made to improve the situation. The fact that, as recently as December 1983, a new interstate mechanism was created for the bay in response to a perceived gap in the network is an indication that interstate cooperation remains fluid in response to changing issues and perceptions. Prior to 1983, no group had dealt principally with water and aquatic habitat quality for the entire Chesapeake Bay drainage area, which is the only logical geographic scope for dealing with estuarine water quality problems. Thus, at the Chesapeake Bay Conference of 1983 an interstate agreement was signed by the Governors of Pennsylvania, Maryland, and Virginia; the Mayor of the District of Columbia; the Administrator of the Environmental Protection Agency; and the chairman of the Chesapeake Bay Commission. A copy of that agreement is

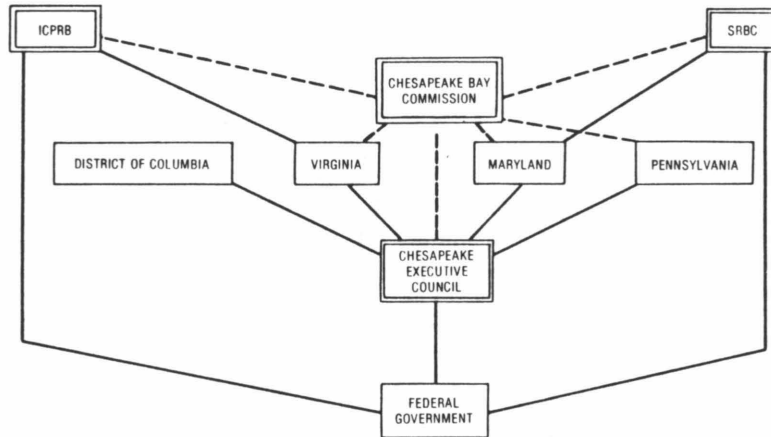


Figure 1. INTERSTATE NETWORK: ENVIRONMENTAL QUALITY

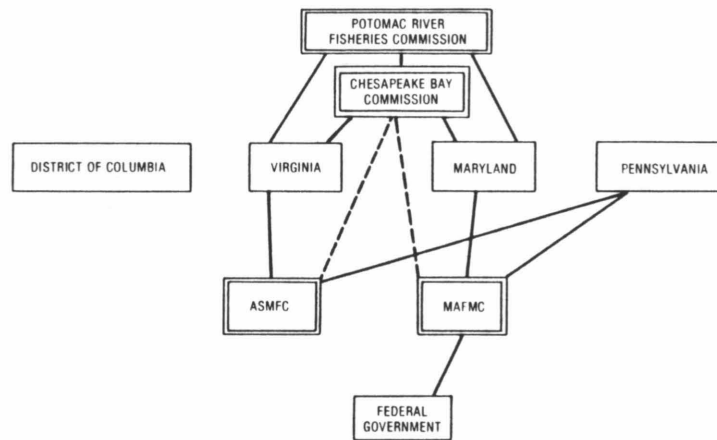
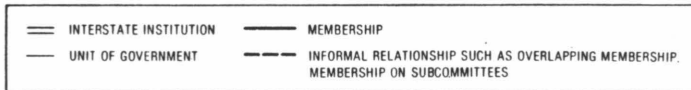
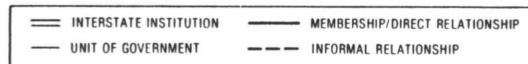


Figure 2. INTERSTATE NETWORK: FISHERIES MANAGEMENT



## The Chesapeake Bay Agreement of 1983

We recognize that the findings of the Chesapeake Bay Program have shown an historical decline in the living resources of the Chesapeake Bay and that a cooperative approach is needed among the Environmental Protection Agency (EPA), the State of Maryland, the Commonwealths of Pennsylvania and Virginia, and the District of Columbia (the States) to fully address the extent, complexity, and sources of pollutants entering the Bay. We further recognize that EPA and the States share the responsibility for management decisions and resources regarding the high priority issues of the Chesapeake Bay.

Accordingly, the States and EPA agree to the following actions:

1. A Chesapeake Executive Council will be established which will meet at least twice yearly to assess and oversee the implementation of coordinated plans to improve and protect the water quality and living resources of the Chesapeake Bay estuarine system. The Council will consist of the appropriate Cabinet designees of the Governors and the Mayor of the District of Columbia and the Regional Administrator of EPA. The Council will be initially chaired by EPA and will report annually to the signatories of this Agreement.

2. The Chesapeake Executive Council will establish an implementation committee of agency representatives who will meet as needed to coordinate technical matters and to coordinate the development and evaluation of management plans. The Council may appoint such ex officio nonvoting members as deemed appropriate.

3. A liaison office for Chesapeake Bay activities will be established at EPA's Central Regional Laboratory in Annapolis, Maryland, to advise and support the Council and committee.

Figure 3. Chesapeake Bay agreement of 1983.

found in figure 3. To be successful, however, any such new institution must fit within the context of the existing network; that is, it must be careful not to usurp existing roles and responsibilities and to focus on a problem or aspect of a problem not being adequately addressed elsewhere. The Chesapeake Executive Council was, indeed, designed with these concepts in mind.

#### Providing for Local Government Participation

The major failure of the network of interstate institutions for the bay is that they have not provided for local government participation in the goal-setting or decisionmaking process. According to Goetze, et al(16), this is the most common failing of interstate institutions. There are probably three reasons why this is so. First, the sheer number of local governments in any multistate area makes representation of every pertinent local government almost an impossibility. Second, local governments, probably unfairly, may be thought to be too parochial and not be interested in the welfare of a water body that extends hundreds of miles beyond their jurisdictional boundaries. Finally, waters, and the living resources within them, have long been viewed as state resources that should be regulated and planned for at the state level.

Only recently, with the completion of the study by the Environmental Protection Agency (EPA) has the full importance of land management to the water quality of the bay and its living resources become known. This relationship makes it exceedingly important that interstate efforts to improve the bay make land management a primary issue to be dealt with. From table 1, it is apparent that no interstate institution for the bay has land management specifically defined as part of its scope or purpose. This omission goes hand-in-hand with the failure of interstate institutions to include local government participation, since land-use planning and regulation has traditionally been the prerogative of local government. Even more than water has been considered a "state" resource, land has been considered a "local" resource. This is particularly true in Virginia. Thus, the need for appropriate use of local land-use controls overshadows the difficulties involved in including local governments in interstate bay efforts.

To be sure, the Chesapeake Bay Commission and the newly formed Chesapeake Executive Council examine and deal with issues that impinge on land use. The commission has examined agricultural best management practices programs, stormwater management programs, and sediment control programs. Seeing that the law in both states dealing with these nonpoint source problems are enacted and implemented to the best of the states' abilities will continue to be a priority. The council will be examining plans that deal with implementing such laws: cost share problems to assist farmers, demonstration projects for stormwater management, etc. Obviously these laws and programs must be properly set up, organized, and coordinated in order that a coherent program of bay improvement may be carried out. However, to have local governments--the governments that are the real actors in land management--truly motivated to exercise their land-use authorities to benefit the bay, they must be tied into the goal-setting and decisionmaking process for the bay.

Local governments have a long history of forming regional groupings for planning and regulatory purposes. The Metropolitan Washington Council of Governments and the Virginia Planning District Commissions are typical examples.

Working with such regional associations of local government would be one way for interstate institutions to overcome some of the barriers to local participation; for example, the large numbers of individual local governments and their tendencies toward parochial viewpoints. The problem is that local governments--given their focus on land and not the impact of land activities on water--have formed regional groupings that are not oriented in any logical way to the bay or its tributaries. The planning district commissions use the rivers as boundaries rather than focal points. Generally, an association of four or more planning district commissions simply would be needed to focus local attention on one of Virginia's river systems; the James River basin would involve nine. Another form of regional government, the soil and water conservation districts, have a similar geographic orientation. Figure 4 and figure 5 show the orientation of the planning district commissions and the soil and water conservation districts to major drainage basins in Virginia.

There are two examples of regional associations of local governments organized along river basin lines in the bay region; they both occur within Maryland. These two organizations are quite different from one another and demonstrate the variety of ways that interstate regional river basin institutions could be formed.

The first such institution is the Patuxent River Commission(17). Formed by state law, this commission has representatives from each local government and each state agency with an interest in the river. This group was charged with coming up with a plan, through land-use controls, the nonpoint sources of pollution entering the river. The Patuxent River Policy Plan was approved in 1984 by the Maryland General Assembly(18). This policy plan is just that--the policy suggests rather than requires that local governments go along--but the level of support for the plan among the involved local governments is very high.

The second multijurisdiction institution is much less formal. The Sassafras River Bi-county Citizens Advisory Committee was formed by citizen activist concerned with water quality in that basin, with much support from county planners, state agencies, and the U. S. Soil Conservation Service. The group might be considered just another citizen's group, except for two facts: First, it is officially sanctioned as an advisory committee to the board of county commissioners (the Maryland equivalent of a board of supervisors in a Virginia county) in both Kent and Cecil Counties. Second, the group has specific representation and cannot leave out any constituency. There are two people (one from each county) representing each of the identified constituencies on the committee: property owners, community associations, commercial waterfront-business, watermen, boaters, and farmers. The county planning officials serve *ex officio*. While this group has just been officially sanctioned by the two county governments, its participants previously operated as a "Forum" and were successful on two counts: (1) getting changes in comprehensive plans and (2) having the Sassafras River named a priority area in Maryland's agricultural best management practices cost-share program(19).

The Chesapeake Bay Program divided the bay into river systems or "segments" in order to better analyze the conditions of the bay as a whole. The states participating in the Chesapeake Executive Council will likely focus their efforts on planning for the improvement of each river system, with an overall purpose of improving conditions in the bay as a whole. If local governments could organize regional associations around each river system, in such a way that they could achieve consensus on water quality and living resource goals and strategies for the

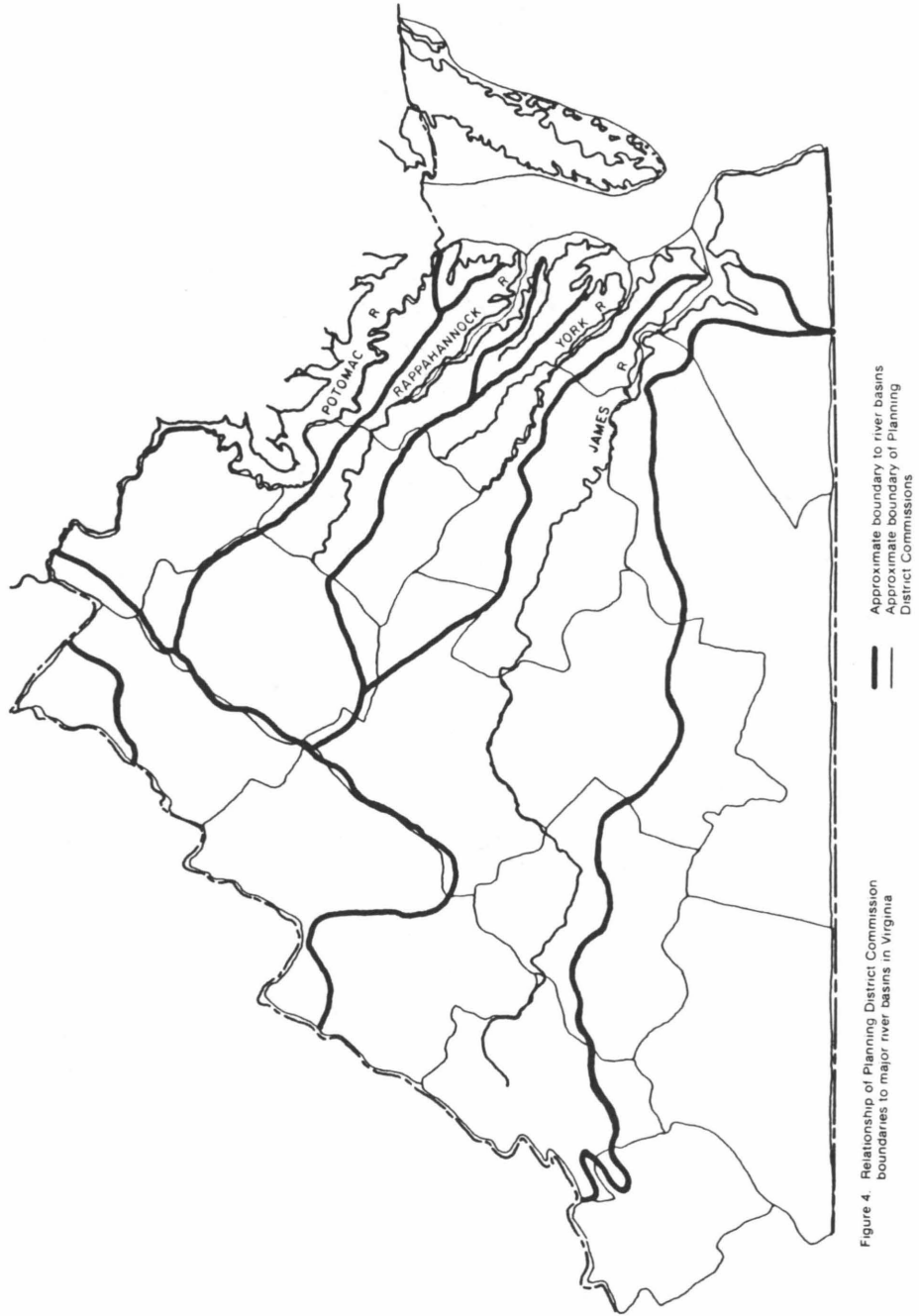
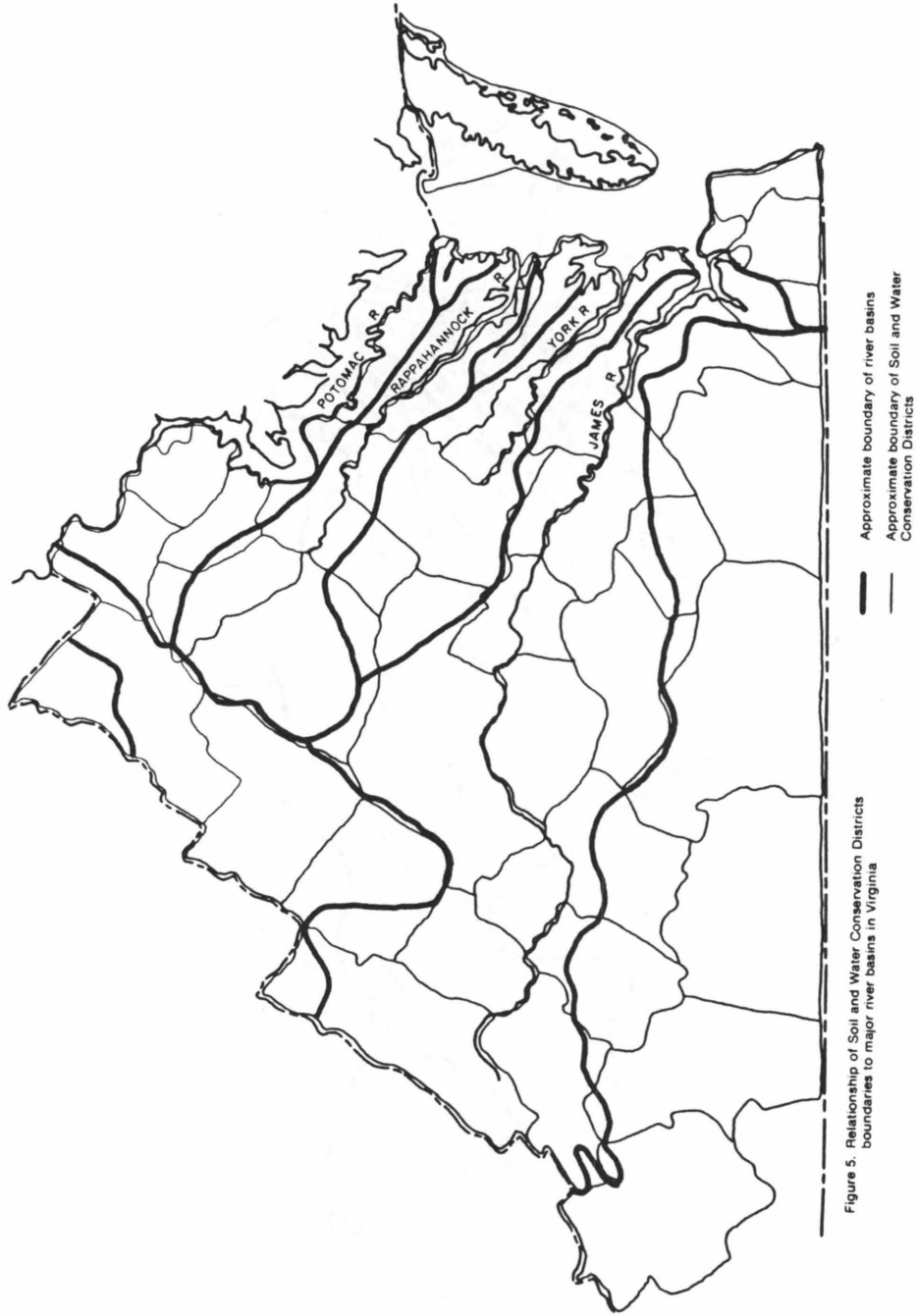


Figure 4 Relationship of Planning District Commission boundaries to major river basins in Virginia

— Approximate boundary to river basins  
— Approximate boundary of Planning District Commissions  
- - - District Commissions



river in question, then their participation in interstate efforts would virtually be assured. Two examples of how such institutions might be organized--one was formally created by a state legislature, the other by local action--are available in the form of the Patuxent River Commission and the Sassafras River Bi-county Citizens Advisory Committee. An infinite variety of other possible intrastate institutions could be formed for the purposes of organizing local governments to agree on goals and strategies for individual river systems in Virginia. Since they are the seat of the land-use authority that is needed if Chesapeake Bay-wide plans are to succeed, it is imperative that means of local participation and consensus building take effective form, with the help and sanction of state government.

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MEASURING PROGRESS IN THE ENDEAVOR OF  
IMPROVING THE QUALITY OF WATER WITHIN AND  
RECEIVED BY THE CHESAPEAKE BAY

By Waldon R. Kerns\*

An important activity of any long-term program for which millions of dollars will be spent is the evaluation component. Evaluation provides a measure of success in meeting the goals of a program. At present, some water quality problems have been identified in the Chesapeake Bay, and some broad ideas have been discussed in relation to the ultimate goals of the Commonwealth's Chesapeake Bay Initiatives. However, a broad consensus does not always exist with respect to specific goals for the various programs that comprise these initiatives.

That a problem exists with respect to nonpoint source pollutants can be demonstrated. The location of some of the most serious nonpoint pollution problem areas has been determined. The following comments on goals and measurement of progress are focused primarily on Virginia's program to control nonpoint sources of pollution, but because it is very difficult and usually undesirable to separate the two, some aspects of point sources are also covered. One objective for the nonpoint program should be clear: that is, to assure the most effective use of limited resources available to the program.

Progress in water quality management must be evaluated in two contexts: by physical parameters in the main stem of the bay, smaller tributaries, and upstream; and by institutional aspects. The institutional aspects have received little attention as the effort has concentrated on physical measurements in the bay and upstream rivers. Monitoring and supporting mathematical modeling studies have been the most widely used method of measuring changes in these physical water quality parameters. The Virginia State Water Control Board, the Virginia State Health Department, academic institutions, and others have conducted monitoring on limited, specialized problems. For instance, data has been provided on fecal coliform impact on shellfish contamination, dissolved oxygen impact on fisheries, chlorine discharges from sewage treatment plants, levels of mercury, fisheries harvest data, the highly publicized measures of kepone, etc. Most often the data collected must be subjected to considerable specialized interpretation by management agency personnel before it can be used effectively. But, monitoring is a very expensive undertaking, and limited budgets have been the primary constraint to more extensive monitoring. Lack of funding will continue to prevent as much monitoring as may be desired in the future.

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### Evaluating Water Quality Parameters

The combination of monitoring and modeling studies has provided a significant amount of background data on many physical and biological parameters for the main stem of the bay. For instance, estimates exist on the amount of nitrogen, phosphorus, and sediment being delivered to the bay's waters. Information has been provided on physical parameters (dissolved oxygen, temperature, salinity), toxic compounds (trace metals and organics), persistent pesticides, and fecal coliform. Biological data on living resources, such as juvenile fish indices, oyster spat, and fisheries statistics, is becoming more available. The monitoring and modeling effort will continue and possibly be considerably expanded under the Commonwealth's Chesapeake Bay Initiatives. A joint program to be conducted by the Virginia State Water Control Board and the U. S. Environmental Protection Agency will have a network of stations on the James, York, and Rappahannock Rivers and several stations in the lower bay for monitoring purposes(1\*). Only one measurement will be made for each river system; this will be made at the fall line, in effect, treating each river as a pipe at the fall line. This monitoring and modeling initiative is a significant development: It is the Commonwealth's first major effort to coordinate the many water quality monitoring and modeling activities.

The major objective of the monitoring and modeling initiative is tracking and recording for "general trend analysis over a period of years" of water quality in the main stem of the bay. A limited effort is planned for smaller scale activities to include studies of the effectiveness of nonpoint best management practices for site-specific areas.

As with the small rivers and tributaries of the bay, limited monitoring has taken place above the fall line. For instance, the Bridgewater office of the State Water Control Board has a monthly sampling program at a few pre-selected stations in the Shenandoah River watershed(2). Several agricultural and industrial related parameters are measured at each station. Also, intensive, site-specific, pilot monitoring programs are being conducted in Page, Rockingham, and Augusta Counties. While these limited samples (12 samples a year) do allow some characterization of pollutants over time, little effort is being devoted to relating those parameters to benefits associated with uses of the water resources.

The small-scale, localized analysis is an important consideration for efficient use of limited resources in a nonpoint control program. As with the main-stem-of-the-bay monitoring program, the measure of quality in upstream areas is applicable only as a general trend over a period of years. Because of site-specific variability, and great variability of hydrology and stream quality, these measures are not applicable to short-term analysis.

The interrelationships between use of nonpoint best management practices on land and the impact on water quality is nebulous at best. Because the ability to relate pollution loads to water concentrations is still imperfect the scientific basis for definitive cause and effect is lacking. Consequently, how much pollution must be reduced to achieve a quality of water that can support a specific living resource or other level of use of the water resource is not known with certainty.

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\*Underscored numbers in parentheses refer to literature cited as references.

As water quality/resource-use cause-and-effect relationships become known, better management decisions can be made. The recent Chesapeake Bay study by the U.S. Environmental Protection Agency clearly demonstrates this point by relating presence of nutrients to decline in submerged aquatic vegetation and the consequent loss of spawning and nursery grounds(3). The study also demonstrates the negative impact of toxic compounds on hatching and survival of fish resources. Impacts on other resource uses such as commercial shipping, domestic water uses, recreation, irrigation, etc., must also be considered. Some effort has been devoted to development of rather arbitrary indices that relate quality measures to suitability of waters for selected uses. However, in most instances, and particularly for nonpoint sources, better site-specific information on cause-and-effect is needed for realistic, localized nonpoint management decisions.

### Use of Institutions in Evaluating Water Quality

Monitoring for biological and physical parameters in the traditional sense of monitoring is only one aspect of the evaluation program. Because program implementation for nonpoint sources control is a major problem, progress with respect to solving institutional issues is just as important as the biological and physical measurements. Since monitoring is by necessity a long-term process, initial emphasis on progress with respect to institutional issues may be a more productive activity.

The Commonwealth of Virginia's recently announced Agricultural Pollution Control Plan for the Chesapeake Bay has three important institutional aspects that distinguish it from past programs and represent an important measure of progress(4). First, primary attention is given to off-site benefits; that is, the impact of changes in water quality on resources such as submerged aquatic vegetation and shellfish will receive increased attention. Past programs have concentrated on traditional on-site productivity measures related to loss of soil and excessive use of plant nutrients and other agricultural chemicals, e.g., pesticides and herbicides. Value will be placed on off-site impacts so that the decisions on kind and amount of controls are more appropriately based on off-site benefit/cost analysis rather than traditional on-site productivity benefits. Output data in the form of improved resource uses, rather than input data in the form of number of BMPs installed, will be used for the benefit/cost analysis. This will permit more efficient management decisions.

Second, a detailed targeting strategy will be used. That is, individual farms or small geographical areas will be targeted for control based on an identified site-specific problem or potential problem. In this way, maximum use of limited funds will be assured.

Third, a variable cost-share rate will be used. The amount of cost-share assistance available will be based on the extent of the problem in a localized area, rather than equal payments to all program participants. In this context, sediment delivered, not simply a measure of soil movement, must become the proper target. Present use of the T-value (tolerable loss of soil) to determine the extent of the problem has many flaws in that it measures soil movement and does not relate directly to sediment delivered to bay waters. Neither does it measure economic cost of any damage to productivity from soil loss. Nevertheless, the concept of relating assistance to the extent of the problem is a step in the direction of a more efficient

use of limited funds. Eventually, use of measures of off-site impacts as replacement of the T-value will improve the process.

These three institutional aspects of the program are not completely new phenomena as they have been used to some degree in recent years. But the fact that they are receiving major emphasis in this program is one important measure of progress.

### The Benefit/Cost Measures of Evaluation

An important measure of progress also will be how well the benefit/cost measures are used to make comparisons with benefit/cost measures of point source controls. Only through use of realistic benefit/cost values can appropriate decisions be made about trade-offs on the most efficient combination of point and nonpoint controls for any given area. Consideration must be given to the economic feasibility of both point and nonpoint controls because cost savings result from using a combination of the two. The methodology and expertise to determine the appropriate combination of point and nonpoint controls exists. Papers presented at a recent conference in Richmond, Virginia, on nonpoint pollution control clearly demonstrate the high level of development of the methodology(5). While the trade-off analysis has received only limited attention in bay management, the Commonwealth's program makes it possible to evaluate the differences among point and nonpoint controls as well as between controls and improvements in resource uses.

A final measure of progress is the more efficient use of resources other than cost-share funds. Cost share is not the only policy tool or management strategy available. Others include: tax credits, loans, charge systems, preferential assessments, insurance, use of taxes, etc. While additional cost-share funds are needed at the outset of the program, the ultimate measure of progress from an institutional perspective could be eliminating the need for cost-share monies. Options other than cost share may very well be more efficient in obtaining desired water quality goals.

The Commonwealth's Agricultural Pollution Control Plan does contain a starting framework to provide site-specific information on cause-and-effect relationships. A tracking system will be used to provide information on reduction in pollutants that are transported to the bay. The program will employ the existing reporting system used by the U.S. Soil Conservation Service (SCS), use of aerial photography to identify potential problems, use limited monitoring on some small watersheds, and use some computer modeling. Some information on the effectiveness of BMPs will be provided by built-in demonstration projects. The main part of the reporting system will provide information on number of practices installed, cost of practices, cost share amounts, source of funds, estimates of soil loss, and estimates of fertilizer applications. The system will also provide an annual evaluation of the influence on farming techniques and changes in farmers' attitudes toward pollution control. But, an effective system must become a management system, not just a report generator. Therefore, the system must be modified to include measures of change in off-site water quality impacts as well as measures of on-site activities.

In summary, the program requires evaluation of the direct impact of land activities on uses of the bay's water: Site-specific criteria that take into account

local conditions in determining use attainability is the key concept. That evaluation should be a foremost objective in measuring progress of the long-term program.

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RESPONSIBILITIES OF INDIVIDUALS, BUSINESS, INDUSTRY,  
AND GOVERNMENT FOR IMPROVING THE QUALITY OF WATER  
IN THE CHESAPEAKE BAY AND THE  
BAY'S SERVICE-PROVIDING CAPACITY

By J. Paxton Marshall\*

In a pluralistic society, good policy is most likely to emerge if concerned citizens--farmers and environmentalists, ranchers and state legislators, rural and urban people--are kept abreast of available and accurate information.

Sandra S. Batie(1\*\*)

Common property will be overused relative to both private property and to public property that is subject to charges for its use or to rules governing its uses; and if the unrestricted common-property resource is depleteable, overuse will in time lead to its depletion and therefore the destruction of the services of the property.

J. H. Dales(2)

Within the Virginia portion of the Chesapeake Bay's watershed there are millions of individuals. Each one of these individuals uses one or more services provided by the bay, and every one of them is totally dependent upon the bay for one service--receiving the runoff-water from the land that he or she uses. Please make a special note: Every one of these millions of individuals is a user of land. Yet almost everyone of these millions of people still have to hear and learn about the concept of common property, especially to develop an understanding that they each individually use the Chesapeake Bay as a common-property resource. Therefore, teaching each of these millions of individuals (including business enterprises) that they have a personal responsibility to reduce the level of pollution in the runoff water from the land he or she uses is an imperative.

People who live at Headwaters, Virginia, which is located in Highland County, near the source of the James River, just as people who live in Rockbridge County, Rockingham County, Fairfax County, or the city of Richmond, find it difficult to believe that they are among the people who use a service provided by the bay.

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\*\*Underscored numbers in parenthesis refer to literature cited as references.

But they do in the same manner that every user of the bay's watershed uses the bay--for the service of receiving the runoff-water from the land that they either own or occupy as user, or both.

An imperative exists in the effort to improve the quality of water within the Chesapeake Bay; this imperative, may be plainly stated: Teach the owners and users of land lying within the bay's watershed the concept of the common-property resource until each such resident or user develops an understanding about the problems of common property. This task requires action by all levels of the educational system, as well as business, industry, government, and individuals. Moreover, the action will result in users choosing among the many alternatives available for improving the quality of the use of land to which they have access, improving the functioning of existing institutional arrangements, establishing (when appropriate) new institutions, and imposing user fees, penalties, and, usually as a last resort, sanctions upon those who blatantly continue to abuse an unrestrained access to the common-property resource, the bay.

### The Concept of Common Property

To the unique assemblage of attributes that comprise land--soil quality, air, soil depth, terrain, temperature, minerals, and a host of others--man has added the concept of property. Property distributes; it distributes rights to receive benefits or to make decisions(3). The effect of rights in private property in land is to grant the owner the authority to regulate use of the land at issue and determine who shall have access to and receive the benefits which may be derived from it, subject, of course, to the rules and conventions society has established. With private property, decisions concerning who shall have access to the use and benefits of the land is determined by the owner.

In contrast to private property, public property is owned by the members of a community, usually a community with a formal governing body, such as that associated with a village, town, county, or city. Where public property is concerned the people of the community determine who shall have access to and receive the benefits which may be derived from such property, and they grant to their government authority to regulate use of the land included in such property.

In contrast to both private property and public property, common property rights are not exclusive to either individuals or government, and such rights cannot be transferred among individuals. Rights in land as common property are held equally by all people of a community. The community may be comprised of a few people, or all of those of a state or nation, or, as in the case of the bay, the people of a watershed--the bay's watershed. Each individual who is a member of the community within which the land at issue lies as common property holds such rights as the system of rules may grant in the property. These rules are always tacit; that is, they are unwritten but applied by mutual agreement among the people who use the property. Because a common-property right does not impose a duty upon the users of the property to maintain the quality of services the property provides, the property is subject to being over-used. As the quality declines and the services that the common property provides also decline or, perhaps, completely disappear, people may act to change common property to either private property or public property.

Clearly the Chesapeake Bay is not held as private property. Moreover, given the structure of our government the bay is not public property, although certain property rights exist that have been converted from common property to public property. These rights have become subject to regulation by government. For example, the right to use the waters of tributaries to the bay and the bay proper for certain services--for example, the production of seed oysters on public seed oyster rock--has become subject to regulation.

The struggle to improve the quality of water in the Chesapeake Bay is inexorably linked to efforts to impose a duty upon each holder of the right--please note the use in the singular of the term right--to have runoff-water from the land he or she owns or uses in the bay's watershed to go into the common-property resource we know as the Chesapeake Bay. The water-runoff right associated with ownership of land within the bay's watershed cannot easily be converted (in all cases) to private property or converted (in all cases) to public property, so the restraint on use of the right must be achieved in other ways: Each user of land must be taught to recognize that he or she has as an imperative duty to contribute to improving the quality of the runoff water.

#### Imposing A Duty On Users of the Water-runoff Right:

##### A Right in Common Property--The Bay

One way to achieve this imperative duty is to create new institutional arrangements. For example, we now have charges for permits required by the National Pollution Discharge Elimination System (NPDES). These charges serve in effect to raise the cost of water discharges from certain private property into common property by placing a cost on such discharges. In turn, these charges serve to impose a duty upon the permit holder to conserve resources, both the private property (i.e., money that pays for the permit) and the common property that receives the discharges, by reducing the load on the common property and thereby contributing to an improvement in quality of services. The imperative duty is imposed, therefore through the NPDES, upon the purse of the property owner or user. This new institutional arrangement also results in additional information about what the water being discharged contains--information that previously was unavailable to government. The availability of this information helps government to develop policy about how to achieve further improvements in water quality.

Owners of land devoted to certain uses, for example, agricultural uses, also may be offered incentives as a way to obtain an improvement in the quality of runoff water. Several programs of this type are currently in effect and others are being developed. These have been successful in cases involving non-point sources of pollution such as large cattle-feeding areas.

Another institutional arrangement would impose a duty on those who benefit from the runoff-water service to assist in financing existing agencies with responsibilities for certain services of the bay, so that the programs of these, often long-established, agencies actually may be implemented rather than being simply "on-the-books." Such an institutional arrangement has been suggested by Professor Shabman(4). His proposed Virginia-oriented "Chesapeake Bay Trust Fund" would be financed by user charges in addition to general fund revenues. Charges would be required of those persons interested in saltwater fishing; these persons are

within a group seeking an improved quality of a particular service from the bay. Shabman also suggests imposing a surcharge upon the user-fee levied for water and sewerage service provided households whose wastewater is discharged into waters which eventually enter the bay. In the first case, the user expects to benefit by obtaining improved saltwater fishing services from the bay after physically traveling there. At the margin, the responsible agency would have funds with which to improve the habitat of and environment available to saltwater fish and, presumably, to increase the numbers of desirable species of saltwater fish. The demand for using this fishing service of the bay may decrease as the number of persons engaging in saltwater fishing would be expected to decline as a result of the user charge. In the second case, if the surcharge on water and sewer bills would be imposed on a percentage-of-the-bill basis rather than a flat-rate surcharge, both decreases in water consumption and sewage discharges would occur as consumers of these services responded to the higher costs by conserving water as measured by use. These and other user fees suggested by Shabman would assist in financing existing agencies with responsibility for certain services of the bay at a level that would, perhaps for the first time, enable them adequately to fulfill their law-assigned responsibilities.

Agencies with responsibilities directly related to the Chesapeake Bay are not the only ones that should be considered when it comes to funding. For example, the knowledge that soil erosion and sedimentation contributes to decline of water quality is widespread. One result was a recent effort to have local soil erosion and sediment control ordinances adopted. This effort proved successful in the adoption stage. However, the evidence is overwhelming that effective administration remains to be achieved at the local level. This situation demonstrates a simple fact; namely, that local government reacts in a manner similar to the individual; if the local benefit is not obvious, local dollars are not likely to be allocated to resolving a problem, especially if the problem is perceived to be hundreds of miles away. Such is the case of the bay relative to the local governments that populate the upper part of the Virginia portion of the Chesapeake Bay watershed. With the state having the clear objective of improving the quality of water in the bay, state financing of a substantial share of the cost of local soil erosion ordinance administration should be carefully evaluated. In addition to the benefits of reducing soil erosion and the resulting sedimentation, the state would send a clear signal that resolving the problem of water quality in the bay has far-ranging benefits, worthy of attention by local governments throughout the watershed.

Each local government has many other opportunities than ordinances to improve the quality of water that runs off the land lying within its jurisdiction. One that an interested locality may want to adopt was proposed by Healy and Short(5). Namely, that a local governing body could develop ways of communicating directly with persons who own land lying within its jurisdiction. One way would be to prepare short messages about the importance of improving the quality of water running off the land. Among the ways these messages could be conveyed would be in the same envelopes as property tax bills or water- and sewer-use bills, or both. Also local government may desire to give special attention to persons who have purchased real property in the community by sending these individuals a letter designed to bring to their attention that which they may never see but which they have a social responsibility to protect--the Chesapeake Bay and its tributaries. The letter also could provide samples of ways in which the new owner can contribute to protecting the common property: Use recommended amounts of fertilizer; place properly any fertilizer used; cultivate the land with care to reduce

erosion; use all chemicals in proper amounts; provide buffer strips for land lying near streams; develop sod waterways to reduce the rate of erosion; and many others. A letter also may be developed and sent to those who purchase real property in suburban and urban areas; they too benefit from the water runoff service and can contribute to improving the quality of runoff-water. Here are two ways they can help: Use special efforts to reduce the daily volume of sewage discharges; sweep daily the sidewalks, curbs, and streets abutting the property purchased. The reader is invited to list other ways persons residing in urban and suburban areas can contribute to improving water quality in the bay.

Business and industry also have a special role to play in getting the people who use land in the bay's watershed to recognize the imperative duty users of the runoff-water right in the bay's watershed have to contribute to cleaning the bay. This role extends beyond the traditional role business and industry have of paying permit fees and taxes, of using care in the manufacture of products and delivery of services, and of developing new materials that result in fewer waste products that contribute to degradation of water quality. Business and industry can take leadership roles in assisting to inform and educate persons about the issue of improving water quality in the bay. At little cost, a small portion of each display ad purchased by individual industries and businesses could be allocated to a message designed to teach those reading the ad about what they could do to contribute to water quality improvement in the bay. The benefit would result from improving the capacity of the bay's watershed to absorb more population, more business, and more industry while increasing both the services of the bay and the productivity of those services. Few can count the revenues flowing into the till with greater care and interest than business and industry; so, applying complementary to expenditures also should be recognized as productive, especially when the result holds the potential for reducing both future government restraints on property use and cost of government.

### The Role of the Land-use Ethic

The struggle to improve the quality of water in the bay and the bay's productivity will require more than creating new institutional arrangements, offering incentives, rethinking the allocation of existing expenditure patterns, and teaching individuals about the problems of the bay, their origins, and their solutions. Eventually a land-use ethic must become a part of the culture. The correct wording of the ethic may be debated for years, but as with the idea of Healy and Short for government officials to send letters as a means of changing habits of land use, a recently published book, Towards A New Land Use Ethic(6), contains a ten-point ethic about how individuals should view and act toward land, whether the land is subject to the rules of private property, public property, or common property. The ten points are:

1. You ought to consider land as a resource that may be yours for a time but is also held in trust for the future. Land is not a commodity that any of us can own in the ordinary sense of the word.
2. You may be a trustee of the land and that will often confer private benefits on you, but you ought not to seek benefits that incur disbenefits on the community or other individuals.

3. If you are presently trusted with the management of a piece of land, you ought to use it in a manner that benefits that land and does not damage it. Some land uses are abuses that have irreversible consequences, and you ought to avoid such abuses.
4. You ought to accept that the use of land should be subject to public scrutiny and control, and exercise your responsibility, with others, in ensuring that no use is permitted that is damaging to society as a whole.
5. You ought to ensure that land-use controls [developed for your community];
  - (a) prevent irreversible damage,
  - (b) avoid waste,
  - (c) protect your natural and cultural heritage,
  - (d) stimulate visual order,
  - (e) regulate and control the unsightly,
  - (f) safeguard individual liberties (like mobility and choice in housing and schooling) so long as those liberties do not impede the liberties of others.
7. You ought to recognize that the exercise of land use controls can only be exercised democratically through government operations. You ought to expect an extension of government to give proper expression of this new land use ethic.
8. You ought to accept that the administration of the ethic must reflect local circumstances and needs, so that it will vary from place to place.
9. You ought to be ready to give time and talent to fight for this means of control which, ironically, is vital for your continued freedom.
10. You ought to recognize that you may have to make some sacrifice, along with everyone else for this control to be effective. [Emphasis in the original.]

An ethic functions to guide individuals and organizations in determining the way they should act in given situations. Each reader is invited to review the ethic above and test his or her response to situations that arise on a continuing basis in making decisions with respect to land use. A vast majority of these decisions individually will have small effects on water quality in the Chesapeake Bay, but in the aggregate the effects can be very large, and the total effect is the effect that counts.

For individuals, business and industry, local government, and organizations, there are many opportunities to contribute to improved water quality in the Chesapeake Bay and thereby enhance its service-providing capacity. To start, remember a simple fact: You can contribute to this effort wherever you may be in the bay's watershed, but most efficiently and effectively by managing the land you occupy and use with improved care. Please note that you can contribute whether you are an owner or a user of land, or both.

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## LEGISLATION AND WATER QUALITY

By John Cairns, Jr.\*

The search for water quality criteria is probably as old as the human race. Before recorded history, water was probably considered "good" if it was not too salty and was not immediately lethal. Even in the age of industrialization, water was considered suitable if it looked and tasted good and fish could live in it. In 1984, the United States Environmental Protection Agency (USEPA) still uses swimmable and fishable as its main criteria! Additionally, regulatory agencies still place heavy reliance on the simple parameters of the last 100 years--dissolved oxygen concentration; biochemical oxygen demand; suspended solids; coliform count; and, more recently, temperature, salinity, and inorganic and organic chemicals including nutrients. Currently, the USEPA is re-evaluating all criteria, but implementation may not quickly follow the process. Today, we continue the search for indicators of deleterious effects in the face of overwhelming evidence that the simplistic criteria and standards of the past are not adequate for today's problem.

Despite more than a decade of fairly intense environmental legislation, it is fair to say that a substantial amount of money has been spent but few of the objectives intended by the legislation have been achieved. Industry, including agriculture, feels vastly overregulated; environmental groups feel that very little has been accomplished; and, the ordinary citizen feels more threatened by inadvertent exposure to hazardous waste sites and toxic contamination of the groundwater supply and the like. As if this were not enough, Canada feels that acid rain caused by industrial emissions originating in the United States has damaged a large number of its lakes and is likely to damage more.

In order to understand why more progress has not been made, one must examine the decisionmaking process. Hazard assessment, or estimating the probability of harm from pollution, is a scientific endeavor requiring probabilistic evidence. The Toxic Substances Control Act (TSCA) recognizes that good science must be the basis for sound environmental legislation by stating that the "evidence shall be provided regarding the hazard to human health and the environment." However, the TSCA has not been enforced (Davies, personal communication). Recommended test protocols have been promulgated, but no guidance has been provided as to what test data should be submitted in a pre-manufacturing notification (PMN). A recent study by the U. S. Office of Technology Assessment showed that most PMNs have no toxicity data at all. Only 17 percent contained any

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data about chronic toxicity, and only 9 percent contained any data on ecotoxicity. Attention has been focused on the administrative ease with which legislation may be implemented rather than on the scientific soundness of the legislation. A few illustrative deficiencies in this regard follow:

1. Present legislation on water quality is a curious mix of "pipe standards," technology-based standards, and biologically-based standards.
2. Regional ecological differences in assimilative capacity for toxic materials that affect water quality are virtually never recognized.
3. Although the goal is to protect entire systems, such as drainage basins, the legislation focuses on one chemical at a time, one discharge at a time, and rarely on the entire system.
4. The criteria in legislative documents are rarely explicitly stated from a scientific standpoint but are usually phrased in nebulous terms such as "fishable, swimmable water," or "protection of fish, shellfish, and wildlife." Scientifically sound validation of their efficacy is impossible with such loosely stated, untestable end points.
5. The attempt to legislate against all risks is technologically and scientifically unsound. The zero-risk concept has been a notable failure, and legislators need to tell the general public what they probably already intuitively know--namely, that every new technology and every course of action involves a certain degree of risk. Science can only determine and reduce the probability of harm, not eliminate it.

Opportunities to solve environmental problems at relatively low cost are often totally ignored because they involve agencies without environmental responsibilities. For example, the PIK (payment-in-kind) program could just have easily called for removing the most highly erodable agricultural land from production instead of leaving the choice primarily to the farmer. Erosion is one of the easiest things to spot as it requires little or no technical knowledge. A quick site visit to the acreage in question could easily permit a determination of whether the most erodable land was being removed from production. As a second example, legislation dealing with surface water and ground water fails to recognize adequately that they are both part of the same hydrologic cycle.

In ChemEcology, April, 1984, the newsletter of the Chemical Manufacturers Association, there was a brief article indicating that biologically-based methods were not yet adequate to set standards, although they were useful. No alternatives were offered, however. Presumably the only practical alternatives are "pipe standards" and technology-based standards.

It is clear that there is no overwhelming support for any one of the three alternatives (pipe standards, technology-based standards, and biologically-based standards). In order to be effective, both the pipe standards and the technology-based standards must use worst-possible-case numbers because they do not use site-specific evidence. This strategy, if carried out fully, will almost certainly result in standards that are unacceptable to industry sometimes because of the technological difficulties in meeting them and when the technology is available, because of the inordinate cost of achieving a level of protection that will work

everywhere in the country. If the standards are relaxed so that they are within the present technology capabilities and/or a reasonable price everywhere in the country, environmental damage is inevitable. This will alienate the environmental groups and a significant segment of the citizenry. On the other hand, the apprehension felt by the Chemical Manufacturers Association about the use of biological methods to set standards is understandable because of the failure of professional biologists to endorse formally an adequate number of methods. They have also failed to provide explicit criteria for determining standards and to state explicitly (as has been done in some other professions) the degree of training necessary to carry out tests to see if the standards are being met. Even with these inadequacies, Section 315a of Public Law 92-600 (permitting a variance to temperature standards if persuasive site-specific evidence is available to document this) has proven satisfactory, although not entirely without fault. There is no question that setting standards for temperature and for potentially toxic chemicals requires somewhat different evidence. On the other hand, some of the field evidence is identical for both assessments. As a consequence, this flexible approach permitting the use of technology-based standards with the option of site-specific, biologically-based standards is probably the best short-term and possibly the best long-term solution.

It is clear that a site-specific determination of standards on a case-by-case basis with different information gathered for each decision will require a cooperative long-range view on the part of industry, the regulatory agencies, the scientific community, and the general public. This hardly describes our present situation. The component that is badly lacking is mutual trust. Regulators do not trust industry to gather evidence. Industry does not feel regulators have industry's best interest at heart, and the scientific community frequently does not trust either industry or government. In fact, pure scientists do not trust scientists who work with "real world" problems.

The bottom line to this is that the science and technology for water quality control and management will not develop in the atmosphere of mistrust that now exists. Not only must different disciplines work together with mutual respect and trust, but organizations representing the industrial, governmental, and private sectors also must work together.

While this working relationship is developing, biologists must develop toxicity tests and other biological measurements for three major purposes:

(1) Screening or rangefinding tests:

- (a) These should be rapid and inexpensive and have wide application.
- (b) Response should have a high sensitivity to stress so the possibility of false negatives is low.

(2) Establishing limitations:

- (a) Tests should be of known precision with exposures that simulate environmental exposures and should be applicable to a wide range of site-specific situations.
- (b) Response should be directly related to environmental hazard, easily interpreted, and meaningful to the public and courts.

- (c) Outputs should be directly translatable into specific decision criteria.
- (d) The end point should be a discrete variable (e.g., death) to avoid the possibility of varying interpretation. If the end point is not a discrete variable, then justifiable decision criteria should be provided.

(3) Monitoring:

- (a) Tests should be rapid and inexpensive and of known precision.
- (b) Response should be sensitive and preferably related to the type of limitation imposed.

If biological evidence, such as toxicity tests, is to be used for regulatory purposes, it must have certain attributes that are functions of the objectives just listed, such as:

(1) Predictive utility based on:

- (a) interpretation--What does the laboratory response mean in terms of environmental hazard?
- (b) extrapolation--Do responses in the laboratory simulate responses in the receiving system?
- (c) sensitivity--Is the response sufficiently sensitive to avoid excessive false negatives? (The sensitivity desired is a function of the objective of the study.)
- (d) variability--Is the precision known or can it be determined and is it sufficiently low to detect impact?
- (e) replicability--For regulatory purposes, toxicity tests must be sufficiently simple and standardized so that they can be carried out by governmental, academic, and private laboratories that have widely varying capabilities. Quality control aspects must be sufficient so that consistent results with acceptable interlaboratory and intralaboratory levels of precision can be obtained.

(2) Decision criteria:

- (a) social relevance--Is the response meaningful to the public and the courts?
- (b) technical relevance--Does the response provide a realistic measure of population, community, or ecosystem level impacts? Is it possible to provide margins of safety based on objective criteria?

- (c) legal relevance--Is the response (that is, end point) usable for establishing limitations on a discharge of a substance? If the response is a continuous variable, is there an objective means of establishing a limiting-exposure concentration to avoid hazard? The "no-effect" level in terms of mortality, as determined in single species toxicity tests, may be the only presently available discrete variable resulting from toxicity or other biological tests.
- (d) cost and timing--Is the cost reasonable in terms of the objectives of the test? Cost is largely a function of the time necessary to carry out tests, space and facilities required, and the level of professional training to get results and interpret them. Decisions as to acceptable cost are largely a function of the degree of certainty required.

Present water quality goals of society are clearly oriented toward protection of important recreational and commercial species, and relatively simple toxicity tests and field studies are thought to provide the needed information for this type of decisionmaking. However, even these species may not survive, even if they are not directly harmed, because the ecosystem upon which they depend has been degraded. The best way to protect the end products of interest to man is to ensure that ecosystems are not degraded. In order to do this more, attention to regional differences will have to be included in the legislation and regulatory practices as well as more flexibility in determining the type of evidence needed for decisionmaking. The increased flexibility means increased reliance on judgment of industry, regulatory agencies, and the scientific and engineering communities. In order for this to work, there must be more trust among the necessary participants in water quality protection.









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