Manure's Impact on Rivers, Streams and the Chesapeake Bay

Keeping Manure Out of the Water

Improving manure management to benefit the Chesapeake Bay, Its Rivers, Streams, and the Watershed's Farmers

A Report by the Chesapeake Bay Foundation

July 28, 2004

CHESAPEAKE BAY FOUNDATION
Save the Bay

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CHESAPEAKE BAY FOUNDATION

BACKGROUND

More than thirty years have passed since Congress first promised the American people that their government would stop the flow of pollution into our rivers and bays and restore them to vibrant health. The Clean Water Act of 1972 made it a "national goal" to bring back "the chemical, physical and biological integrity of the Nation's waters" and to end "the discharge of pollutants into the navigable waters" of America by 1985.

That target date is far behind us now, and on the shores of the Chesapeake Bay, as well as on the banks of thousands of miles of its streams and rivers, the Clean Water Act's promise is still unfulfilled. A generation of children has grown up with a diminished birthright. Few of them have the chances all should enjoy: to swim in a local river, dip a net into clear water chasing crabs, or stretch out on the banks of a neighborhood stream watching fish rise to feed on newly hatched damsel flies.

Local rivers and streams are no longer sparkling and thriving with aquatic life, and many are seriously damaged by pollution and in need of restoration, according to the U.S. Environmental Protection Agency. The Bay's seafood harvests are in decline, its watermen are losing work that helped our region prosper, and all of us are losing a way of life that makes Bay Country unique, from the Tidewater to the Great Shenandoah Valley and the mighty Susquehanna.

The vast Chesapeake watershed feeds the most productive bay ecosystem in the nation. Scientists have studied it more and understand it better than perhaps any water body in the world. In an era when people tended to think that pollution came solely from poisons like DDT, Bay scientists were among the first to realize what the world now understands: Too much of a good thing can amount to a deadly overdose.

Human settlement in the Bay watershed has sharply increased the amounts of two key elements, nitrogen and phosphorus, flowing into Bay waters. These natural plant nutrients are essential to healthy ecosystems. But in excess, they cause explosive growths of algae and other underwater plants, which literally suffocate other forms of Bay life. Bay scientists' computer models estimate that the Chesapeake now gets hundreds of millions of pounds of nitrogen and tens of millions of pounds more phosphorus than it did in the 1620s, when Captain John Smith encountered a Bay in perfect natural balance, so bursting with health and productivity that the English explorer joked about catching fish with a frying pan.

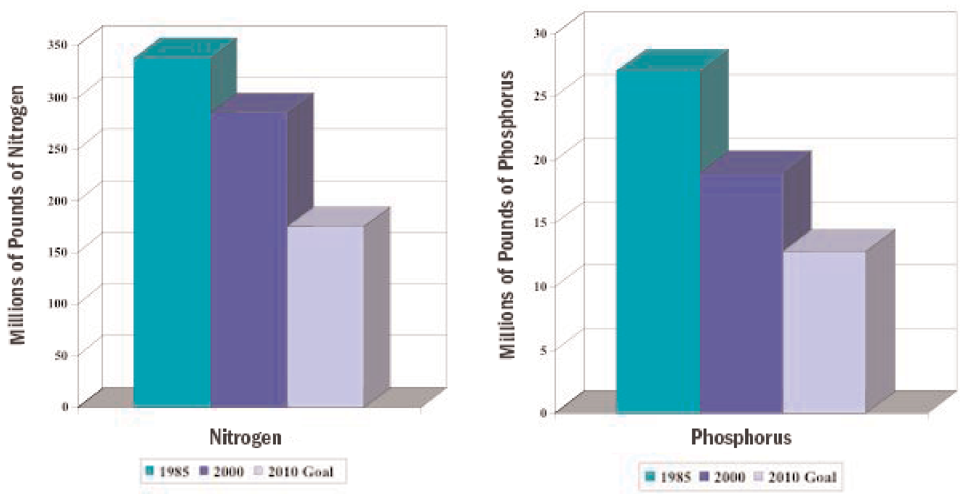
The Chesapeake Bay is choking on nutrient pollution from a myriad of sources – from urban runoff, industry, automobiles, and human sewage, but the largest source is agriculture and, increasingly, from the manure produced by livestock, which now outnumber the watershed's human population by 11 to 1. Most of that manure is spread on the surface of nearby cropland, and studies show that within two years as much as half of its nutrient pollution washes out of the soil and into rivers and streams or seeps into groundwater. Both of these pathways lead to pollution in local waterways and, ultimately, in the Bay.

Since 1983, the Bay has been the focus of a pioneering restoration program that now involves six states, the District of Columbia, and the federal government and affects all of the region's 16 million citizens. The most basic goal is to sharply reduce the amount of nitrogen and phosphorus reaching the Bay and its tributaries. Twenty years of concerted effort have reduced the flow of nitrogen into the Bay by 15 percent, even as population grew by 17 percent. This is a significant achievement -- but the payoff, a healthier Bay, still hasn't been achieved. Recognizing the need to do more, government leaders set even more ambitious nutrient reduction goals when they reaffirmed their commitment in the Chesapeake Bay 2000 Agreement.

The Bay restoration effort is at a tipping point, on the brink of either success or failure. The outcome may have global significance. Nutrient overdoses threaten coastal communities around the world, with potentially severe consequences: infestations of toxic algae, diminished seafood production, and lost recreation and tourism opportunities.

Scientists at the Chesapeake Bay Program have recently finished an analysis of the nitrogen and phosphorus reductions that would restore healthy oxygen levels, improve water clarity, permit Bay grasses to rebound, and take the Chesapeake and its tributaries off the "impaired waters" list by the year 2010. This would meet the Clean Water Act's ultimate goal: clean streams and rivers flowing into a restored Bay. The scientists found nitrogen flows into the Bay would have to be cut by an additional 39 percent, from 285 million pounds a year to 175 million. Phosphorus flows would need to be reduced by an additional 33 percent, from 18 million pounds a year to 12.8 million.

Chesapeake Bay Nitrogen and Phosphorus Pollution



Source: EPA Chesapeake Bay Program

In the Chesapeake 2000 Agreement, leaders from Virginia, Maryland, Pennsylvania, the District of Columbia and the federal Environmental Protection Agency pledged that by 2010 nutrient levels would fall low enough to allow the grasses to cover 185,000 acres. They also committed to making sure that the nutrient reductions accomplish two other key elements of the restoration: permitting dissolved oxygen to return to appropriate levels throughout the Bay and improving water clarity by reducing levels of chlorophyll A, a plant pigment used to measure algae growth.

Once these lower nutrient levels are reached, the Bay region leaders also agreed to a nutrient "cap" to ensure that future pressures from population growth, land development, and economic growth do not erode the progress made in nutrient reductions. However, to date, none of the Bay states has proposed a set of policies to accomplish this.

The challenge is significant. Progress needs to be three times as fast as it has been up till now or the new pollution reduction goals will not be met. Governments at every level, along with businesses and citizens, must focus on actions that will yield measurable, significant, and permanent pollution reductions and result in real water quality improvements.

Data compiled by the Chesapeake Bay Program show that animal waste and human waste (sewage systems and septic tanks) contribute 40 percent of the nitrogen that drains into local streams, rivers, and the Bay. In effect, we are still using the Bay and its tributaries to dispose of our wastes. The old adage that the "the solution to pollution is dilution" is an outdated, environmentally destructive notion that needs to be banished from 21st century America. Nutrients are a valuable resource and should be managed more efficiently for both economic and environmental benefit. The Bay watershed, which encircles the capital of one of the most technologically advanced nations on Earth, should be a global leader in this effort.

Last year, the Chesapeake Bay Foundation issued a Sewage Report, that analyzed the amount of pollution being discharged by sewage treatment plants in the watershed and called for the implementation of available, affordable technology to reduce that pollution. Agriculture is the largest source of nitrogen and phosphorus pollution in the watershed. This report is designed to analyze the impact of animal waste on local rivers, streams, and the Chesapeake Bay and identify steps that must be taken to reduce this pollution.

LOTS OF ANIMALS MEANS LOTS OF MANURE:

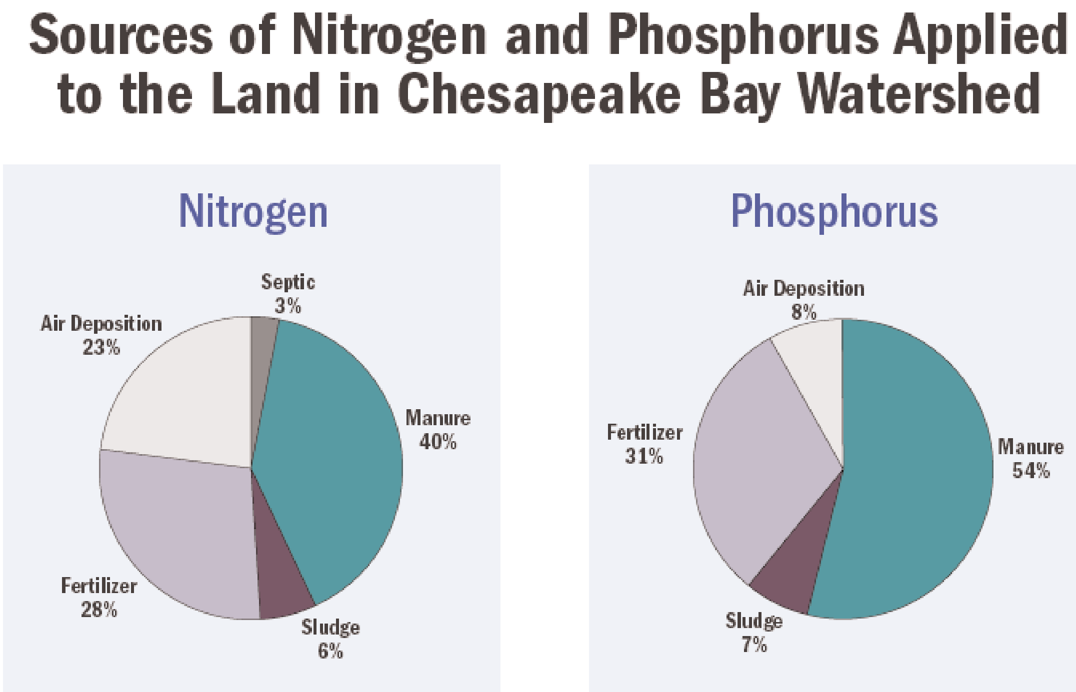
As public consumption of meat products has increased in recent decades, the number of livestock in the watershed has grown, and livestock operations have become more concentrated. There are six major types of animal operations in the Chesapeake Bay watershed: dairy cows, beef cattle, pigs, egg production, broilers (chicken meat), and turkeys. Taken together, there are 185 million livestock animals present in the Bay watershed at any one time – more than 11 times the human population. These animal operations excrete 44 million tons of manure each year containing nearly 600 million pounds of nitrogen.

Animal Manure Generated in Bay Watershed

Animal Type	Number of Animals	Pounds of Nitrogen	Pounds of Phosphorus
Beef	1,846,923	208,979,305	74,153,947
Dairy	697,595	161,380,163	25,103,581
Swine	1,254,026	38,448,422	14,647,018
Poultry	181,560,180	185,873,604	51,780,397
Total	185,358,723	594,681,494	165,684,943

Sources: EPA Chesapeake Bay Program, 2003

The Chesapeake Bay has more land draining into it relative to its volume of water than any other bay in the world. This fact alone makes it extremely vulnerable to the pollutants that come off the land. Of the nitrogen and phosphorus that are placed on the land, animal manure is the largest source. According to data compiled by the Chesapeake Bay Program, animal manure accounted for 40 percent of the total nitrogen and 54 percent of the total phosphorus deposited on the land – which has a limited capacity to absorb and retain it and in many places has already exceeded that capacity. That pollution has seriously damaged the health of local rivers, streams, and the Chesapeake Bay.



Source: EPA Chesapeake Bay Program

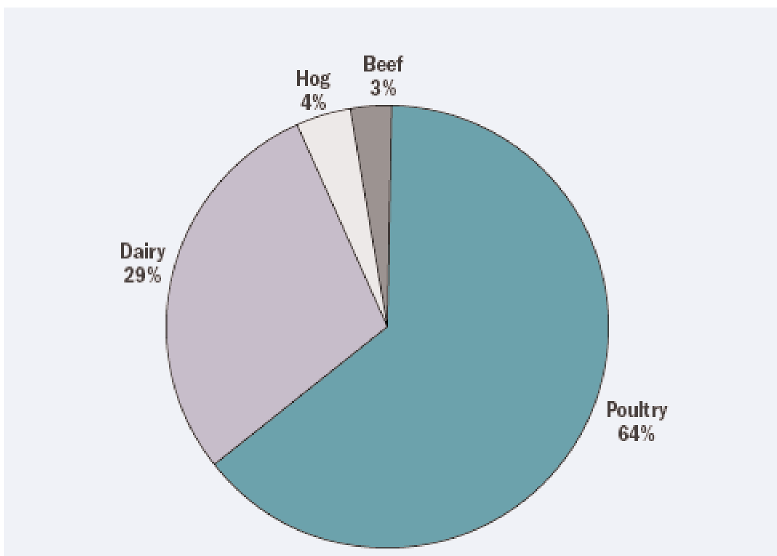
Manure can be both a waste product and a resource. It is spread on farm fields for two reasons: to fertilize crops, and at times simply, because there is not enough storage for all of the manure. Once it is put onto farm fields, there are numerous in which nutrients are lost from the cropland and wind up in streams and rivers. Soon after it is spread, large amounts of ammonia gas, a nitrogen compound, can escape into the atmosphere. Much of that ammonia falls on land nearby, contributing to air and water pollution. About half of the manure's nitrogen is in a form plants cannot absorb until soil microbes break it down into ammonium, nitrate, and other usable forms. The plants take all the nutrients they need through their roots and leave the rest in the soil, where nutrients can build up past the soil's capacity to hold them. Then these nutrients can seep into groundwater, which flows invisibly into the Bay, or be washed by rain into streams that feed the Bay. Manure nutrients can build up the soil's phosphorus levels to the point where no additional phosphorus fertilizer is needed for crops. At that point, the farmer must find another use for the manure, either someone else's crop field or an alternative use. However, if another use is not available, then, from the farmer's point of view, the manure is no longer a resource but a waste with no obvious means of disposal -- and from the environmental point of view, it is a dangerous pollutant.

Over the last 15 to 20 years, the total amount of manure has not changed substantially, but the nutrient quantities have. Poultry manure is higher in nutrients than cow manure, and the poultry industry has been expanding in the region, while milk and beef production have declined. The amount of manure nutrients generated in the watershed has grown about 17% since the early 1980s.

One of the most significant changes in animal agriculture is the use of confined animal operations. These are large barns or sheds specifically designed to house a very large number of animals – from hundreds to thousands -- in close quarters, where they are fed, watered, and medicated in standardized amounts. Nearly all poultry and most pigs and some dairy cows are raised in confinement, whereas beef are still primarily raised in pastures and only moved to confined operations prior to being slaughtered.

By confining the animals in a single place, large amounts of manure are collected and stored in facilities such as a waste pit, lagoon, or a storage shed. This collected waste is referred to as “recoverable manure” to distinguish it from the manure of free-ranging animals, which is difficult if not impossible to collect. Recoverable manure can be applied to cropland as fertilizer, the most common use. Even though poultry only generates 15 percent of the Bay region’s total manure by weight, it comprises two-thirds of the recoverable manure nitrogen. Conversely, beef, which generates one-third of the total manure nitrogen, produces only three percent of the recoverable manure. A total of 232 million tons of recoverable manure nitrogen is generated in the Bay watershed annually.

Recoverable Manure Nitrogen by Animal Type in Bay Watershed



Source: Weber and Kellogg, 2001

MANURE FERTILIZER IS INHERENTLY INEFFICIENT

For centuries, manure has been used to fertilize crops. Prior to World War II, manure was the dominant source of fertilizer. While manure provides numerous benefits to soil quality, it has significant drawbacks as well.

- Manure is bulky and difficult to transport long distances, so it is usually spread close to the farm where it was produced—which over time leads to build up of nutrients in the soil, making them more susceptible to runoff.

- Manure’s nutrient content varies more than that of manufactured fertilizer. That makes it difficult to apply exactly the amount needed. Standard agricultural recommendations call for testing the nutrient content of manure before spreading it, but that isn’t always done, and farmers often use general estimates to decide how much to use.

- Manure spreaders commonly used today cannot precisely apply small amounts of nutrients.

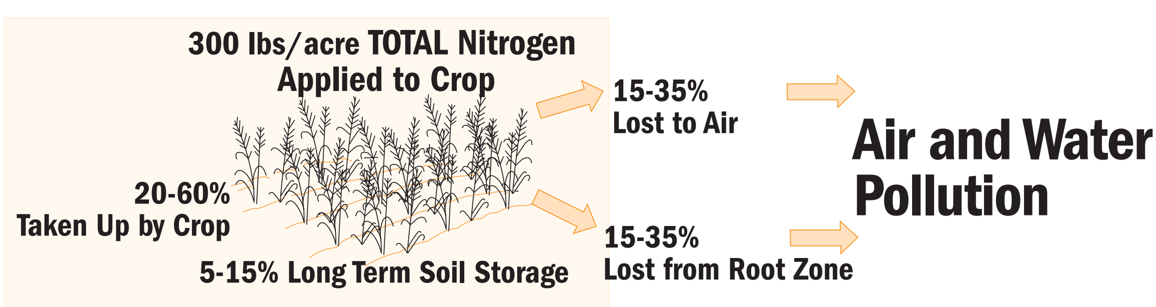
- Manure must be applied before the crop emerges from the ground or it will bury the young plants. But when using commercial fertilizer, farmers can apply it in two separate batches—one when the crop first goes into the ground and another when the crop is about to begin a growth spurt. If farmers test the soil's nutrient content before the second application, they can often use less nitrogen, save money, and reduce the likelihood of polluted runoff. The need to apply manure early in the growing cycle eliminates that option.

- Manure's ratio of phosphorus to nitrogen is higher than the ratio that crops need. Thus a farmer who applies enough manure to meet the crop's need for nitrogen is over-applying phosphorus. The unused phosphorus builds up in the soil, and these elevated levels can greatly increase phosphorus pollution. If farmers limit manure applications to prevent phosphorus buildup in the soil, they must also apply commercial fertilizer to meet the crop's nitrogen needs, therefore requiring additional time and cost from the farmer.

- Crops can take up only a fraction of the total nutrients contained in manure. The rest may volatilize into the air, leach into ground water, or run off the surface when it rains. Many Bay watershed farmers must prepare "nutrient management plans" designed to minimize fertilizer waste and polluted runoff. But typically the plans compensate for evaporated or unusable nutrients by increasing the amount of manure applied, often resulting in more nitrogen and phosphorus than the plants can absorb.

Recent research at the University of Maryland and the USDA has shown that if manure is not properly incorporated into the soil, 15 to 35 percent of its nitrogen can volatilize, escaping into the air. Most of the remaining nitrogen is in a form that plants can't use until soil bacteria decompose it, and that process takes time. About 50 percent of the manure nitrogen is unavailable to the plant during the first growing season and remains in the soil after the crop is harvested, making it susceptible to leaching and runoff. An additional 20 percent of the total nitrogen may be broken down by bacteria and available for the next year's crop. Of the amount that is unused by the crop, 5 to 15 percent stays in the soil for numerous years. The exact fate of manure's nitrogen will vary from year to year depending on the weather conditions, plant growth, and a farmers' management practices. However, in general, over a typical two-year crop cycle roughly 50 percent of the manure nitrogen applied to the land may be vented into the air or washed into ditches and streams and eventually may enter local waterways and the Bay.

Typical Nitrogen Budget for Corn Using Manure as Fertilizer

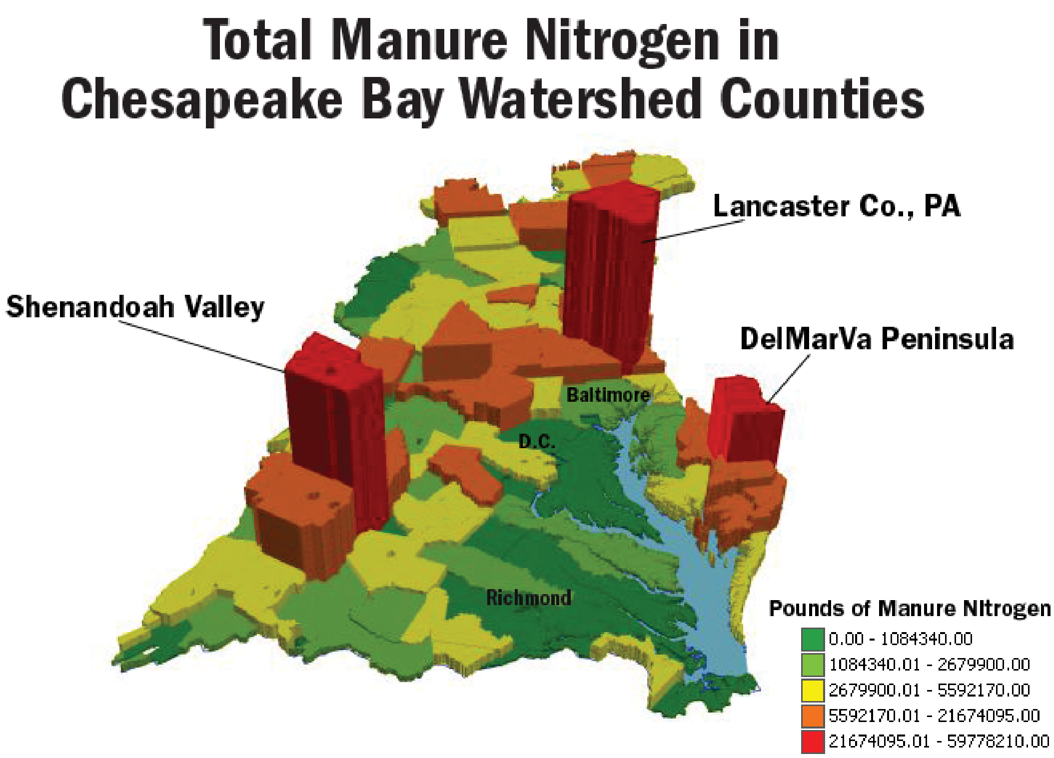


Source: USDA Agricultural Research Service, 2004

LIVESTOCK-RAISING REVOLUTION LEADS TO BAY POLLUTION

Gone are the days when every farm had a small number of livestock, with chickens, pigs, and cattle sharing the same barnyard. In order to achieve economies of scale, animal farmers today specialize in a particular type of livestock. The number of animals commonly raised on a single farm is now five times greater on dairy farms, ten times greater on hog farms, and 100 times greater on chicken farms than it was fifty years ago. Additionally, large, multinational corporations that now dominate much of poultry and hog production have consolidated most of the meat production process. These large corporations have created networks of farms and supporting businesses to carefully control the steps in producing the meat, from the animals' birth to feeding, slaughtering, and the preparation of ready-to-eat foods. As a result, animal production has concentrated in regions where the consolidated infrastructure for meat production is located. Because of this specialization and concentration, rather than animal production being spread out across the landscape, there are far greater numbers of livestock in certain regions of the country.

Although agricultural production is widespread throughout the Chesapeake watershed, there are three major animal production regions with the greatest concentrations of livestock: the Lower Susquehanna River in Pennsylvania, the Shenandoah Valley in Virginia and West Virginia, and the Delmarva Peninsula in Delaware, Maryland, and Virginia. The Delmarva Peninsula is dominated by integrated chicken production. The Shenandoah Valley also has a large network of chicken farms as well as turkey production and considerable beef and dairy farms. The Susquehanna Valley has very diverse and still mostly independent animal production led by dairy and beef operations along with eggs and some hog and chicken farms.



Source: EPA Chesapeake Bay Program

MANURE HOT SPOTS

The three manure hot spots in the Bay watershed cover 23 percent of the watershed's land area but contain 54 percent of all manure nitrogen. In these hot spots, the water quality issues of manure are the most acute and must be the focus for solutions:

- Lancaster County, PA, in the Susquehanna River basin, has the second-highest agricultural production of any county east of the Mississippi River and ranks fifth in livestock production nationally. The county, which represents only 1.5 percent of the area in the watershed, produces more nitrogen from manure than any other county in the Bay's drainage area – 72 million pounds a year, about 12 percent of the total nitrogen from all manure sources in the watershed.

- The Delmarva Peninsula is one of the top chicken producing regions in the nation, led by Sussex County, Delaware, the nation's highest chicken producing county. Also, Worcester County and Somerset County in Maryland, although they do not produce the sheer number of chickens as Sussex County, the number of chickens raised per acre of cropland to receive the manure is higher.

- Rockingham County, VA, located in the Shenandoah Valley, is the largest turkey producer in the nation and the largest dairy and chicken producer in Virginia. Its animal operations have more excess manure than any other county in the nation according to calculations from USDA.

In these concentrated animal production regions, large amounts of feed, along with the nitrogen and phosphorus they contain, are imported to meet the demand of all of the animal operations. This creates a huge imbalance between the amount of nutrients coming into the region as feed and the amount going out as agricultural products. This imbalance can occur on individual farms as well when an animal producer does not have enough land to handle all of their manure. As a result, large amount of nutrients leave the region through the air and water in the form of pollution.

When a nutrient imbalance exists on a farm, in a county or in a region, there is more manure than the crops in that same area can utilize. It is this excess manure that is the most likely to find its way into groundwater, local streams and the Bay. Bay states have yet to compile data tracking of when and where manure is applied to the land. Therefore estimates of excess manure vary substantially depending on the assumptions that are made. For example, most estimates assume that the manure is spread on all the cropland in a county, and that no commercial fertilizer is added to the county's nutrient supply.

Using the best available information, the USDA's Natural Resource Conservation Service (NRCS) has calculated excess manure for each county in the country. The USDA information shows that the three Chesapeake manure hot spots have huge amounts of excess manure. When these figures are compared to a similar analysis completed by USDA's Economic Research Service (ERS) for the entire Bay watershed using national averages for amount of land where manure is applied, it shows that the three manure hot spots contain the vast majority of the total excess manure in the entire watershed. This excess manure has damaged local streams and rivers and delivers very large amounts of nitrogen and phosphorus to the Bay.

These estimates are based on the amount of phosphorus available compared to what the crops need. Until recently scientists thought that unneeded phosphorus would bind to the soil and stay put, but research has now established that once the soil reaches a saturation point, it begins releasing phosphorus into surface and ground water. Recognizing this, the Bay states have drawn up new requirements that farmers include phosphorus in their nutrient management plans, and the states are at different stages in the process of phasing in these new rules.

Excess Manure Calculations

For Animal Production Regions in Chesapeake Watershed
Under Phosphorus Based nutrient management plans

Location	County Excess Manure Tons
Lower Susquehanna (NRCS)	286,196
Middle Delmarva (NRCS)	257,268
Shenandoah (NRCS)	600,070
Total Bay Watershed (ERS)	1,500,000

Deadlines are now upon farmers to start applying manure based on a crop's phosphorus needs. Virginia started requiring poultry growers to have phosphorus based plans in

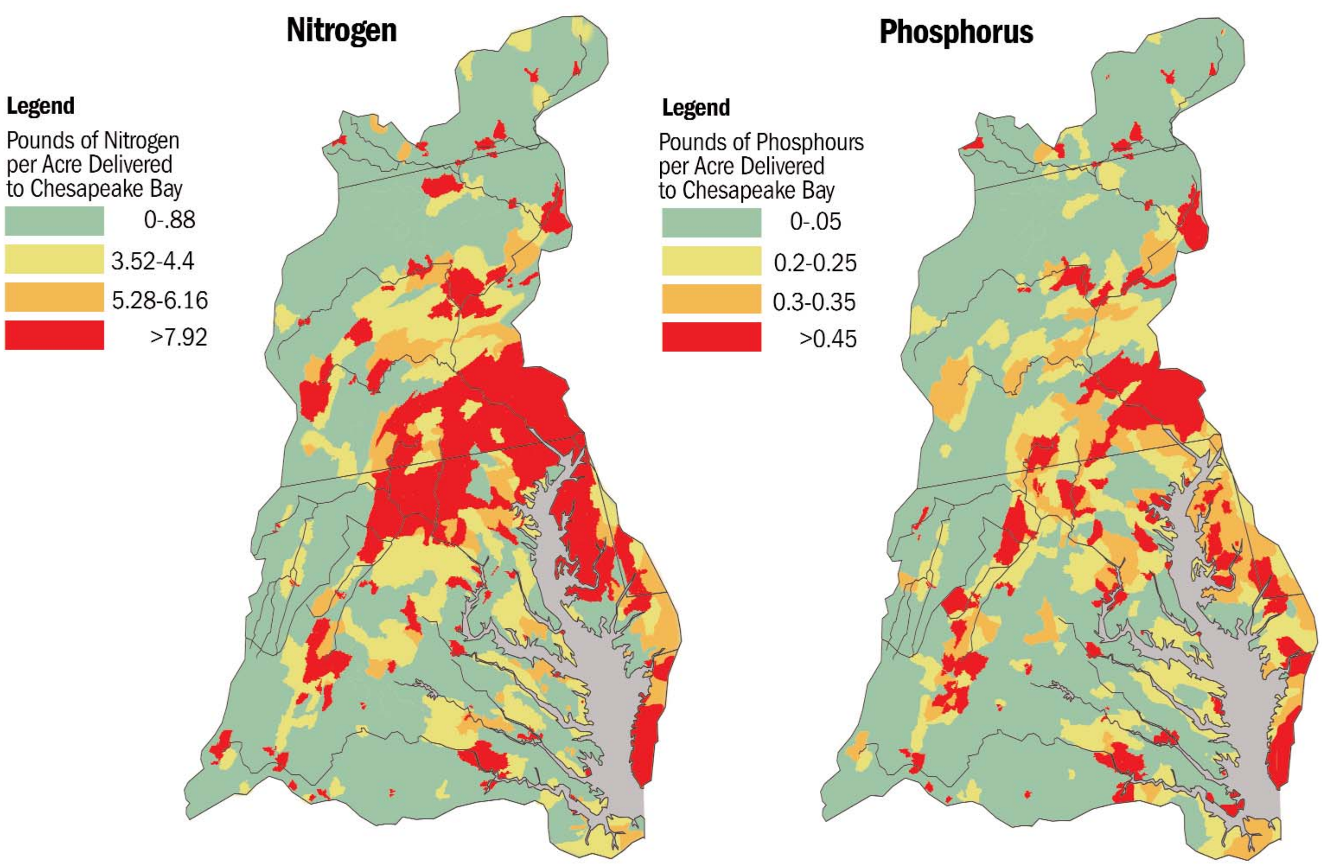
2001 and will be revising their regulations for other operations by the end of 2005. Delaware began requiring phosphorus based plans in 2003 and will reach full implementation in 2007. Pennsylvania ruled in May 2004 that all new nutrient management plans required under their nutrient management law must address phosphorus as well as nitrogen. In Maryland, the deadline for including phosphorus in nutrient management plans for manure applications was July 1, 2004, but implementation of that plan is not required until July 2005.

As nutrient management programs have begun to more fully address manure applications, additional needs have been identified. Pennsylvania, which enacted the first nutrient management law in the watershed, is now expanding the program to include farms that receive exported manure as well as requiring certification by manure transporters and setbacks from streams for manure applications. Maryland, Delaware, and Virginia have all started manure transport programs to help move excess manure out of hot spots. Maryland has also increased funding to pay farmers to plant winter cover crops that help soak up excess nutrients after crops are harvested.

TOO MUCH MANURE—A RESOURCE BECOMES A POLLUTANT

The amount of nitrogen and phosphorus actually reaching the Bay varies according to local factors, such as soil types, proximity to major rivers and to the Bay, and the size of streams that drain the area. Healthy, small streams

Geographic Sources of Nitrogen and Phosphorus Polluting the Chesapeake Bay in 1997

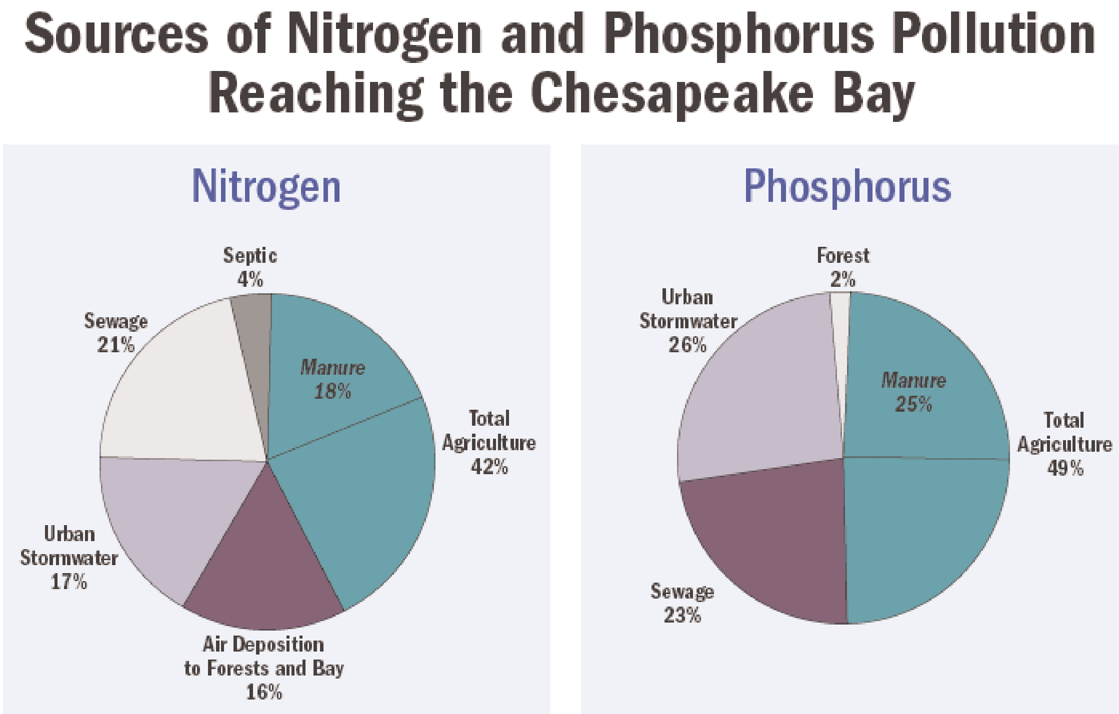


Delivered yields of total nitrogen and total phosphorus from all sources in the Chesapeake Bay watershed, 1997. [Delivered yield is the amount (load per area) of total nitrogen that is generated locally for each stream reach and weighted by the amount of instream loss that would occur with transport from the reach to the Bay.]

Source: Adapted from USGS, draft data, 1997.

can absorb large amounts of nutrient-laden runoff from farmland, passing it along to plant life along their banks and in the streams themselves. Large rivers with higher volumes of water absorb relatively fewer nutrients, so a greater proportion of the nitrogen and phosphorus washing off land along their shorelines actually ends up in the rivers and the Bay. The U.S. Geological Survey has done an area-by-area assessment of the nitrogen and phosphorus reaching the Chesapeake, after factoring in the cleansing effects of small streams. The map below illustrates the USGS finding that the region's three animal production hot spots generate large flows of pollution into the bay.

Of the nitrogen and phosphorus that reach the Bay, agriculture is the largest source and animal manure is the largest agricultural component. Chemical fertilizers and airborne pollutants such as ammonia gas—a common manure by-product – make up the rest of the agricultural sources. This makes animal manure not only the largest source of nitrogen and phosphorus deposited on the land, but also the second largest source that reaches the Bay, behind sewage, which is deposited directly into the water. Animal manure is a major source of the Bay's pollution and must be addressed swiftly and comprehensively.

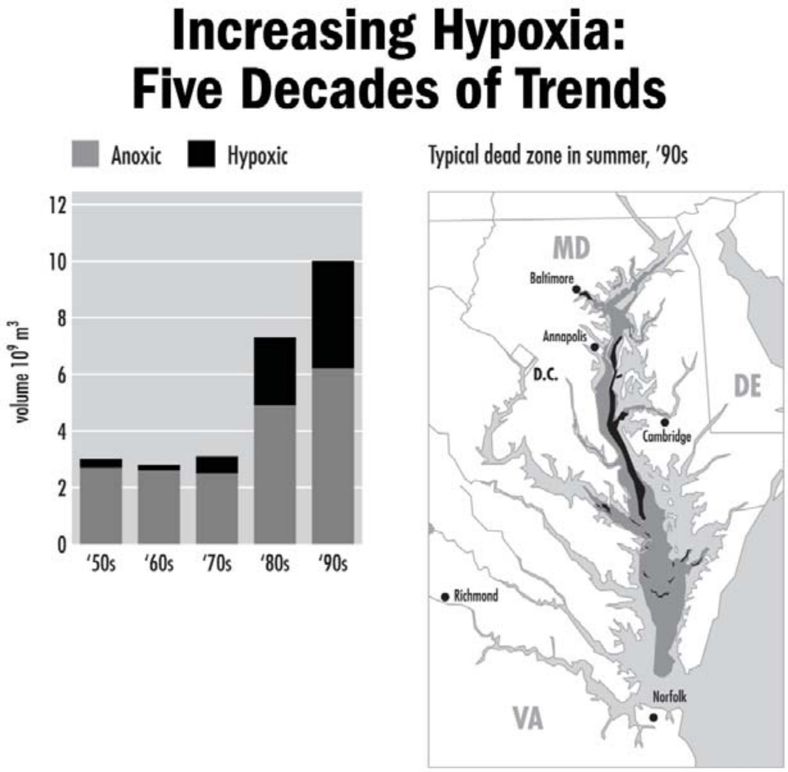


Source: EPA Chesapeake Bay Program

DEAD ZONES DRIVE BAY CREATURES FROM VITAL HABITAT

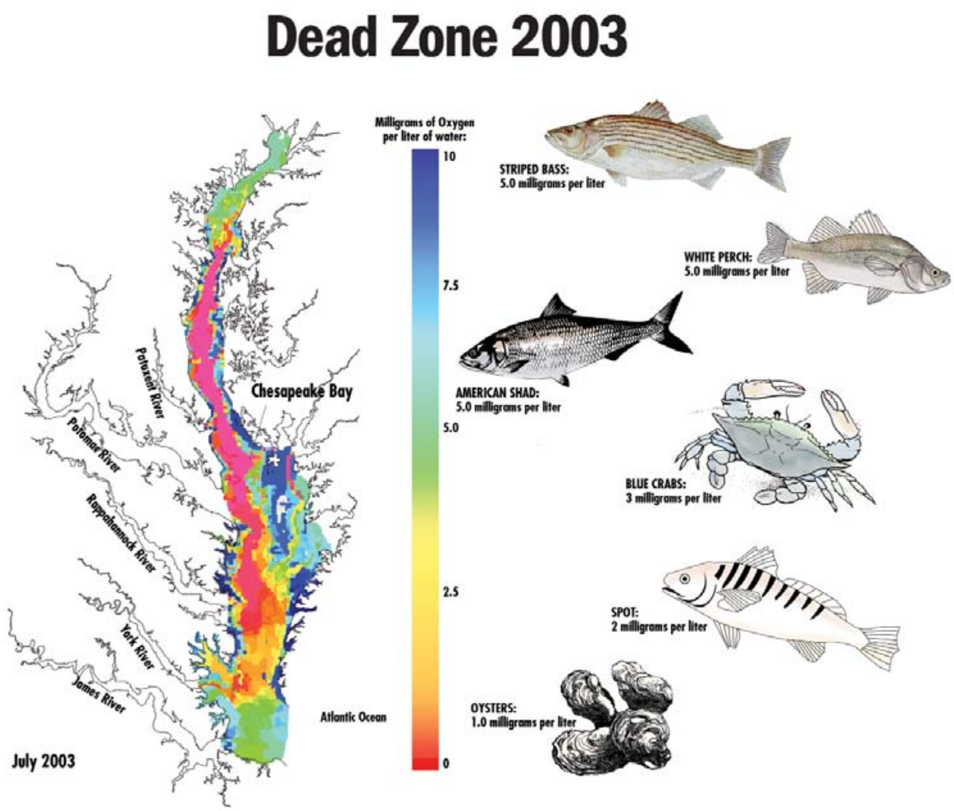
The excess nutrients from manure and other sources such as sewage treatment plants trigger excessive algae growth (blooms), which eventually die and decompose in a process that consumes oxygen. Algae blooms use up so much oxygen that parts of the bay become low in oxygen, or hypoxic, and sometimes completely void of it, or anoxic. These "dead zones," cannot sustain healthy aquatic life, and represent a major loss of important habitat for fish, crabs, oysters, and other species of historic economic and cultural importance. Every year dead zones are found in deep water, which contains less oxygen than surface waters to begin with. But when wind patterns affect the bay's circulation, the dead zones can move into shallow water, forcing fish and crabs to flee and killing those left behind such as ones caught in watermen's nets or traps.

In spite of the nutrient reductions achieved so far, dissolved oxygen levels in the Bay and its tidal tributaries have shown little improvement. On average, monitoring data shows the Bay's main body has unhealthy or lethally low oxygen levels from May through October or November.

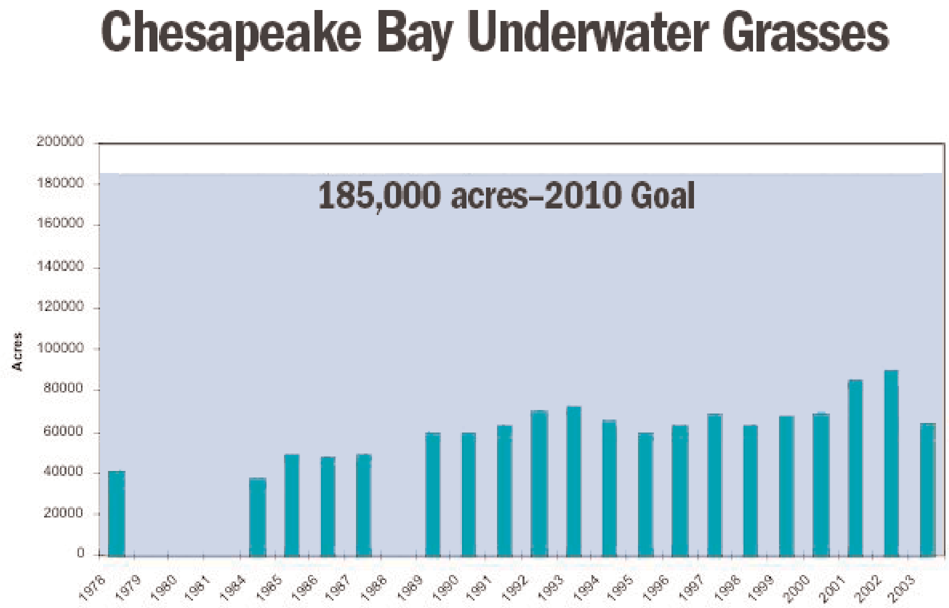


In July 2003, the Bay suffered one of the largest areas of oxygen depletion since the Chesapeake Bay Program began monitoring oxygen levels 20 years ago. The affected area, approximately 40 percent of the Bay's central portion, or mainstem, began at the Patapsco River near Baltimore and stretched more than 100 miles south to the mouth of the York River near Hampton Roads.

Excess algae also blocks sunlight from reaching the bottom, making it impossible for underwater grasses to survive. These grasses, known as submerged aquatic vegetation or SAV, are essential to a healthy Bay. They produce oxygen that is added to the water column, improve water clarity by holding bottom sediments in place with their roots, and provide irreplaceable shelter and feeding grounds for the bay's most important aquatic species, including blue crabs, striped bass, spot, croaker and many others.



Scientists think underwater grasses probably once grew in much of the sandy or muddy shallows of the bay and its tributaries – any place where the grasses could sink roots and get the sunlight they need. But in the 1960s they began disappearing at an alarming rate. Underwater grasses are so important that scientists at the Virginia



Institute of Marine Sciences conduct an aerial survey each year to map their extent. They reached an all-time low in 1984, when they covered less than 10 percent of their potential habitat. They have since rebounded, but still grow in less than half the acreage they did before the decline began. Additionally, in 2003 when nitrogen pollution levels were the second highest in 15 years, the grasses declined by 30 percent.

MANURE POLLUTION HARMS LOCAL WATERS

Nutrients

Similar to impacts in Bay waters, excess manure nutrients often exceed local waterways' capacity to absorb them, with devastating results. Just as in the open Bay, reduced levels of oxygen in these rivers and streams can drive away aquatic life, inhibit aquatic plants' and animals' ability to survive and reproduce, and cause fish kills. When algae growth blocks light penetration, these waterways can lose their underwater grasses, which provide essential local habitats for aquatic creatures.

Some of the excess nutrients from cropland move through surface soils and bottom sediments into groundwater, with potentially serious, long-term consequences. Groundwater is a source of well water for human and animal consumption. It is also the source of more than one-half of all the water flowing in most of the streams of the Chesapeake watershed, according to recent USGS research.

Locally high nitrogen levels pose a potential risk to human health and the health of young livestock. High levels of nitrate in drinking water can cause "blue baby syndrome," a potentially fatal condition that prevents infants' blood from absorbing oxygen. The evidence on many other human health effects is not conclusive, but some studies have linked high nitrate levels to bladder cancer and other cancers. High nitrate levels have also been shown to cause spontaneous abortions in cattle. The federal government sets 10 milligrams per liter as the maximum allowable amount of nitrate in drinking water, and government data shows groundwater levels are often higher than that in the animal agriculture hot spots.

The U.S. Geological Survey (USGS) has conducted in-depth investigations of the Delmarva, the Susquehanna, and the Potomac River Basin as study sites for its National Water Quality Assessment program, which analyzes water samples from selected streams and aquifers. The assessment found that nutrient levels in shallow groundwater in the three Chesapeake manure hot spots are among the highest in the country. Additionally, federal and state monitoring and studies have further documented deteriorated groundwater and stream conditions in these regions.

- In the Lower Susquehanna, the USGS found nitrate levels exceeding 10 milligrams per liter in 36 to 45 percent of its groundwater samples. Pennsylvania has 12,262 miles of streams that are listed as "impaired," or unable to meet the Clean Water Act's description of healthy waterways. The Pennsylvania Department of Environmental Protection says agriculture is the source of the impairment for 3,903 miles of streams -- about one-third of all the state's tainted waters. The state's data do not show how much of the impairment is specifically due to animal manure. But in a separate study in 1998, the USGS concluded that animal manure used as fertilizer was the Lower Susquehanna's main nitrogen source.

- Nitrate is widespread in shallow groundwater on the Delmarva Peninsula, including parts of the underground aquifer used for drinking water. About one-third of the shallow wells sampled had nitrate levels above the federal safe drinking water standard. A recent USGS study found the highest concentrations were beneath sandy soils and might be related to the presence of manure piles. According to the Maryland Department of the Environment, approximately 71 percent of the stream segments on the Delmarva Peninsula are unable to support healthy populations of fish or the bottom-dwelling creatures that are a key link in the aquatic food chain. Statewide, 51 percent of streams are listed as impaired, or unhealthy, due to nutrient pollution. Data from the Maryland Biological Stream Survey shows the same trend; nitrate concentrations in Maryland streams generally increase in tandem with increasing proportions of agriculture.

- In the Shenandoah Valley, the USGS found nitrate concentrations were among the nation's highest. Nearly one-fourth of water samples taken from the Potomac Watershed and areas of porous rock showed nitrate levels above the federal 10-milligram standard. When compared to natural conditions, nitrate levels were elevated in farm areas more often than in non-farming areas. In a study of the entire Potomac River basin, the USGS concluded that animal manure accounted for 29 percent of the nitrogen and 45 percent of the phosphorus distributed throughout the basin, with the greatest inputs of nitrogen and phosphorus in the Shenandoah Valley. A study of water quality and fish in Muddy Creek, a tributary of the Shenandoah River in Rockingham County, Virginia, found that nutrient levels were in the top 25 percent of all streams sampled nationwide, and the fish communities were correspondingly more pollution tolerant.

Green Run Watershed Study

Upper Pocomoke River, Maryland and Delaware

The upper Pocomoke River basin is in the heart of the Delmarva poultry country and has some of the highest concentrations of poultry farms in the country. It has streams that are impaired by nitrogen and phosphorus and high groundwater nitrate levels. It is also the location of a small watershed study that may hold the key to achieving local and Chesapeake Bay water quality goals.

Beginning in 1998, the Maryland Department of Natural Resources and the local county conservation district teamed up to compare universal adoption of agricultural practices in one watershed to the current levels of implementation in the neighboring watershed. For four years, all of the farmers in one small watershed employed three practices: nutrient management, winter cover crops, and moving all poultry manure outside the watershed.

Over the course of the four years, nitrogen levels in the stream dropped by 25 percent in the study watershed while they remained unchanged in the unaltered watershed. The total amount of nitrogen put onto cropland was cut in half, primarily due to the replacement of manure with commercial fertilizer applied according to nutrient management plans. Additionally, cover crops helped absorb leftover nitrogen after crop harvest. Phosphorus runoff stayed the same in both the study watershed and the unaltered watershed most likely due to high levels in the soil that existed prior to the study and that will take additional years to decrease.

This study shows both the promise and the challenge of reducing nutrient pollution from manure. Clearly, achieving large reductions in nutrient runoff and the associated dramatic improvements in water quality is possible and in a relatively short period of time. However, these results required 100 percent participation by the farmers and significant changes to their operations. Replicating those two factors across the Chesapeake watershed will be much more difficult.

Bacteria

Both human and animal waste pose a significant threat to surface waters within the Chesapeake Bay watershed by introducing disease-producing organisms to areas in which we swim, fish, and enjoy other kinds of recreation. They can also contaminate shellfish beds, closing them to harvest. State environmental agencies check for fecal matter in waterways by testing samples for a group of indicator bacteria known as fecal coliforms, including Escherichia coli, which can cause human health problems.

- In Virginia, more than half of the state's rivers that are designated as impaired by the Department of Environmental Quality are degraded by fecal matter. The same is true in the Shenandoah Valley, where over 500 miles of streams are impaired by fecal coliforms.

- In Maryland, approximately 15 percent of impaired waters are due to the presence of fecal coliforms; however on the Delmarva Peninsula, about 57 percent of stream segments are impaired by the fecal bacteria.

- Pennsylvania does not routinely test for bacterial contamination in surface or groundwater, making it impossible to assess the scale of the problem. However, fecal bacterial contamination was found in nearly 70 percent of household wells in the Lower Susquehanna River Basin, with higher levels of contamination in agricultural areas than in forested ones, according to a USGS study.

Fecal contamination originates from a variety of sources, including humans, livestock, poultry, and wildlife. There are few studies that definitively identify the cause of high fecal coliform levels. However, scientists have developed new "bacterial source tracking" (BST) techniques that employ genetic fingerprinting and similar methods to identify the various warm-blooded animals contributing to fecal pollution. In Virginia, several studies have used BST to estimate relative sources of bacterial contamination.

EMERGING ENVIRONMENTAL ISSUES RELATED TO MANURE

Trace Metals

Animal feed contains copper, zinc, and selenium,

BST Studies in VA

Bacterial source tracking (BST) techniques have been employed on several local streams in the Shenandoah Valley of Virginia. Researchers from James Madison University isolated fecal bacteria from two creeks in a cattle-grazing area in Rockingham County, Virginia, and found cattle contributed to 72 percent of the samples from Cooks Creek and 68 percent of those from Muddy Creek. A similar study conducted by Virginia Tech scientists in rural Page Brook, an impaired stream in Clarke County, identified beef cattle that had "unrestricted access" to the brook as the source of fecal bacteria found in 78 to 86 percent of bacteria samples taken during the warm season. After fences were installed at the most contaminated site to exclude livestock from direct access to the stream, the number of fecal coliforms was reduced by 96 percent during warm season sampling.

A USGS study released last year used genetic fingerprinting to identify sources of E. coli on two streams impaired by fecal coliform bacteria in the Shenandoah Valley. The study identified multiple sources of fecal contamination in both streams -- Christians Creek, an agricultural watershed in Augusta County, and Blacks Run, an area of mixed urban and agricultural land use in Rockingham County. In both cases, cattle and poultry were the top two sources of fecal bacteria. Even though the Blacks Run watershed is two-thirds urban and one-third rural, agriculture contributed more than 55 percent of the E. coli contamination.

Bacteria levels followed a seasonal pattern that paralleled agricultural practices, the USGS study found. From April to September, when cattle numbers increase, cattle bacteria sources increased. Poultry growers typically spread chicken manure on fields in the cooler months, and the researchers found more poultry bacteria during those months. The total fecal bacteria levels were highest in the summer and early fall.

which are essential micronutrients. However, the feed often has more of these trace metals than the animals can absorb; the excess is excreted into animal manure, according to researchers at the University of Delaware. Arsenic goes into poultry feed to stimulate the animals' weight gain, help them process feed more efficiently, and make their meat a more attractive color. As a result, poultry manure contains arsenic. A study by researchers in Alabama found that when manure is applied to the land repeatedly, toxic metals can build up in the soil. At present, there is no strong evidence linking land application of poultry manure to trace metal contamination in water or sediments. Because arsenic poses a cancer risk to humans, the USGS and Johns Hopkins University have studies underway to determine what ultimately happens to manure arsenic.

Hormones

Hormones are potentially the most troublesome of the manure-related contaminants. They are endocrine disruptors – natural or manmade substances that can change the endocrine systems of creatures exposed to them in the environment. The endocrine system governs basic physiology, such as the development and functioning of reproductive organs. Documented effects of endocrine disruptors in fish and wildlife vary, from subtle changes in the physiology and sexual behavior of species to obvious deformities of the reproductive organs.

Naturally produced estrogen and testosterone are among the hormones found in manure. While some cattle-raising facilities use synthetic hormones, most of the hormones contained in manure from the Bay watershed are naturally produced. The synthetic hormones from cattle-raising facilities have been linked to reproductive effects in fish. When fathead minnows, a widespread aquatic species, were exposed to very low levels (in the parts per billion range) of a synthetic growth promoter in laboratory studies, EPA researchers found that the females showed reduced fecundity and masculine traits. Researchers at the University of Maryland found that exposure to naturally produced substances found in poultry manure can have similar effects. In laboratory studies, they exposed fathead minnows to water extracted from poultry manure and found that the minnows' reproductive organs were affected. The Maryland researchers suspect that estrogen in the litter is at least partially responsible.

The question of whether hormones contained in manure are escaping into the environment and harming wildlife is a new and controversial area of research. There is a growing body of evidence

Removing the North Fork River from EPA's "Dirty Waters" List

South Branch of the Potomac, West Virginia

When the North Fork River was placed on EPA's "Dirty Waters" list in 1996, local farmers, citizens and a multiagency project team set out to clean up the river. The farms in the watershed are dominated by intensive beef and poultry operations that are located on flood-prone areas adjacent to the river. Water quality was impaired by nutrient and fecal bacteria pollution and a USGS study found a strong relationship between fecal bacteria concentration in streams and the numbers of animal operations per mile.

Through a combination of federal and state funding sources and substantial private investment by the farmers themselves, a multitude of agricultural practices were installed including feedlot relocation, stream fencing, alternative watering systems for cattle, animal waste storage, barnyard improvement, streamside buffers, and composting facilities. Nutrient management plans were implemented more widely and livestock feed was altered to improve phosphorus efficiency. Many of the practices benefited farmers economically as well as improving water quality.

As a result of this coordinated effort and funding, nitrate and fecal bacteria levels decreased in the stream to the point where the state and EPA removed the North Fork River from the impaired waters list in September 2003. In achieving this remarkable accomplishment, more than 85 percent of the farm operations participated in a full suite of agricultural practices. This success story demonstrates that reducing pollution from agricultural operations is achievable, but it will take widespread implementation and must address all aspects of farming operations.

suggesting that the runoff from livestock facilities contains hormones, and that the hormone levels are high enough to harm aquatic organisms. For example, a study conducted on the Eastern Shore of Maryland found that run-off from fields to which chicken litter had been applied contained estrogen at levels known to elicit reproductive effects in fish. A recent U.S. Fish and Wildlife Service study conducted in the Chesapeake watershed found estrogen in surface waters on the Delmarva Peninsula, but not at a Patuxent River site on Maryland's Western Shore that was distant from large-scale animal agriculture. The Fish and Wildlife Service researchers tested the blood of male carp for a substance called vitellogin, a biological tracer that signals exposure to endocrine disruptors, and found it in significantly higher levels in Delmarva fish than in fish collected from the Patuxent. Similarly, Clemson University found detectable levels of estrogen in ponds that received run-off from beef cattle pastures, and female painted turtles in those ponds had higher levels of vitellogenin than turtles from ponds that had no run-off. According to a study of Nebraska cattle feedlots led by a St. Mary's College researcher, natural and synthetic hormones were detected in downstream waters. The researchers concluded the hormones were probably having harmful reproductive effects on fathead minnows living downstream.

Antibiotics

The Union of Concerned Scientists estimates that as much as 86 percent of the antibiotics used in the United States is given to livestock. Growers give pigs, cattle, and poultry low doses of antibiotics to promote growth and higher doses to treat disease. The animals excrete large amounts of the antibiotics, unchanged. Thus the chances are high that these antibiotics will end up in the environment. For example, the Fish and Wildlife Service's Chesapeake study found low levels of tetracycline in poultry manure, and also found measurable concentrations of tetracyclines in streams adjacent to agricultural fields on the Delmarva Peninsula. In a nationwide study, USGS found at least one type of antibiotic in 48 percent of the streams surveyed. The ecological consequences of widespread antibiotic contamination are not fully known, but doctors who specialize in infectious diseases fear that if microbes are exposed to antibiotics in the environment they may develop resistant strains, making the drugs ineffective in the treatment of human and animal illnesses. Antibiotics also could alter microbial processes that are important to the functioning of healthy aquatic ecosystems.

Air Pollution

The Bay states' ambitious new nutrient reduction goals make it essential to identify all the sources of nitrogen pollution in the Chesapeake Bay watershed and to reduce them. With that in mind, scientists are evaluating livestock production as contributor to atmospheric nitrogen pollution. The Chesapeake Bay Program estimates that 27 percent of the nutrient nitrogen reaching the bay comes in the form of airborne ammonia and nitrate. The main agricultural sources of atmospheric ammonia are confined livestock operations, which use fans to vent the potentially lethal concentrations of ammonia gases emitted by large amounts of animal waste in a small, enclosed space. Manure storage and handling can also allow ammonia to be lost to the air with uncovered pits and lagoons for liquid waste being the most susceptible. Researchers at the Universities of Maryland and Delaware estimate that ventilation from poultry houses on the Delmarva Peninsula emits over 40 million pounds of ammonia nitrogen each year.

Manure spread as fertilizer can also raise atmospheric ammonia concentrations. Generally, the greatest amount of nitrogen is lost between the time the manure is applied and the time it is worked into the soil. USDA researchers estimate that manure spread on the soil commonly can release from 5 to 35 percent of its total nitrogen into the air, depending on management practices and environmental conditions. Surface applications of liquid manures can lead to the largest and most rapid losses.

Recently, regulators have paid greater attention to air pollution from animal operations, specifically ammonia and small particulate matter. States are currently in the process of determining what areas exceed air quality standards for these pollutants and will require emission control measures to be implemented. As research and monitoring increasingly show that animal operations are a significant source of these pollutants, strategies must be developed to control emissions. Feed adjustments, manure amendments, exhaust filters for confined livestock operations, and avoiding surface application of manure on cropland have all shown promise in reducing manure emissions. These measures will reduce water pollution to streams and the Bay as well as improve air quality.

KEEPING MANURE OUT OF THE WATER

Throughout history, the impacts of human waste from the concentration of people in cities and towns created obvious, grave environmental and health problems. Conversely, animal populations were more dispersed across the countryside, making it possible for the land to better absorb their manure. But large-scale animal production has now concentrated livestock animals in similar if not greater densities than human populations. Therefore, specific actions must be taken to prevent animal waste from polluting local waters and the Bay. The problem has become so pervasive that much greater investments in manure management must be made if we are to achieve healthy waters throughout the Bay watershed.

Three key strategies must be used to attack the problem:

- Reduce the amount of pollutants in manure.
- Ensure that there are adequate safeguards to prevent runoff when manure is applied to land.
- Create alternative, non-polluting uses for all excess manure.

Farm operations vary greatly and so do their environmental settings. Thus no single approach will be enough to restore the region's impaired streams and rivers and clean up the Chesapeake Bay. Rather, the problem of manure pollution must be approached strategically, with cost-effective strategies specifically designed for each sector of the farm economy. Taken together, these strategies can make the necessary reductions in manure pollution and sustain a healthy farm economy.

The Chesapeake Bay region's agriculture, like the entire nation's farm economy, does not operate under the same laws of supply and demand that govern most other businesses. The agricultural economy has been shaped for decades by commodity price supports, federal government purchasing programs, and a myriad of other market-altering programs. The programs are intended to support farmers and farming, to provide the nation with inexpensive food, and to develop a strategic advantage in the international market. Under this managed approach, the demand for basic farm commodities does not fluctuate much, and neither do the commodities' prices. This makes it very difficult for farmers to pass along any increased costs to consumers. Farmers cannot raise their rates, as a wastewater treatment facility can. Nor can they change their products' features or packaging to make them more appealing to consumers. They must sell a standard commodity in a global market. Therefore, financial incentives and technical assistance are important to successful manure management strategies.

Reducing Manure Nutrients

When it comes to manure, the common saying "garbage in, garbage out" might be paraphrased, "pollution in, pollution out." The pollutant content of manure is determined by the animal feed. Better feed management can be one of the most cost-effective means for reducing manure pollution. Feed management is also one of the few methods available to reduce the pollution from non-recoverable manure that is directly deposited on pastures by grazing animals, and can allow better management of recoverable manure that is spread on the land. Moreover, feed alterations can change the chemical properties of manure in such as way as to reduce ammonia losses. Promising research has been conducted to develop feed adjustments to reduce the amount of nutrients in manure, particularly for poultry and dairy. Since mounting evidence shows there is reason for concern about the human and environmental risks of trace metals and pharmaceuticals in manure, additional work is needed to reduce the level of these compounds.

Poultry growers are already adopting poultry feed adjustments to reduce the phosphorus levels in manure, and these adjustments are required in some Bay states. Recent research has demonstrated that phosphorus content in manure can be reduced by 40 to 50 percent without affecting the health or marketability of the bird by avoiding surplus phosphorus in feed and adding phytase, an additive that allows chickens to absorb more phosphorus from their feed. Phytase additions are being used in nearly all poultry operations throughout the watershed. On the Delmarva Peninsula the overall result has been an 16 percent reduction in manure phosphorus.

Hogs and poultry absorb nutrients in similar ways and much of the early research on the use of phytase was conducted on hogs. It is widely used in Pennsylvania and has reduced phosphorus in hog diets by approximately 16 percent. Agricultural researchers in Maryland and North Carolina are trying to refine phytase and other feed management techniques to make them more effective for hog and poultry operations. The costs of these changes, and new information about the maximum reductions that are possible without harming productivity, will be the controlling factors in programs to reduce nutrients in feed.

Recent research in the development of dairy feed indicates that excess nitrogen and phosphorus levels could be significantly lowered without reducing milk production or nutritional value. With less nitrogen in dairy feed, the amount of nitrogen that ends up in waterways could be reduced by as much as 40 percent. Since a significant portion of dairy manure is non-recoverable – on pasture land rather than in a barn where it can be collected and managed – reducing the nitrogen content of manure is the only feasible way to reduce pollution from such a diffuse source.

Reducing nitrogen in cattle feed could also save the dairy industry money. Most dairy feed contains supplements to boost its protein content, but both university and industry research indicates that protein supplements can be reduced substantially with no ill effects on the milk's quantity or quality. Scaling back the amount of crude protein in dairy feed could yield overall savings to the dairy industry in the Bay watershed of about $18 million per year.

Some dairies are switching from confined operations and formulated feeds to pastured dairies where grass is the primary feed for the cows. This approach can substantially reduce polluted runoff from these operations and avoid the nutrient pollution associated with applying manure to cropland. Although milk production is normally lower on grass-based dairies than confined operations, they often are more profitable because of lower costs.

Safeguards for Land Application

When manure is applied to cropland as fertilizer, there is an inherent pollution risk. Since land application is currently the preferred use of manure, strategies must be employed to minimize polluted runoff or leaching. Steps must be taken to minimize losses when the manure is applied. Manure must be incorporated into the soil soon after application. This effectively prevents ammonia from escaping into the air, prevents soluble nitrogen and phosphorus from running off in surface water during a rainstorm, and slows down phosphorus saturation in the soil surface.

Currently, the vast majority of manure is spread onto the soil before planting, although some liquid forms of manure are injected into the soil. In order to till manure into the soil, farmers must do extra work at one of their busiest times of year, and they must have the appropriate equipment. Furthermore, many farmers have been encouraged to use no-till techniques, leaving crop stubble in their fields and leaving soil surfaces undisturbed, in order to reduce erosion. More research is needed to determine which types of landscape can tolerate manure tillage without increased erosion and how much tilling must be done to prevent nutrients from seeping into waterways.

After crops are harvested, significant amounts of nutrients remain in the soil that can be subject to leaching or surface runoff during the late fall, winter, and early spring. Winter cover crops are highly effective at holding nutrients on the field between growing seasons. Cover crops are one of the most cost-effective means to reduce nutrient pollution and must be more widely planted each year. Planting cover crops at the optimum time is often a major logistical obstacle to farmers trying to harvest fall crops. Innovative incentives and alternative planting methods that address farmers' time constraints are needed for greater adoption of this important practice.

Finally, even with extremely careful management of manure applications and the use of manure cover crops, nitrogen and phosphorus will still be lost from a modern crop field striving for maximum yield. Therefore, riparian buffers – streamside strips of trees, shrubs, and grasses that capture nitrogen and phosphorus from runoff and groundwater ––are a crucial final line of defense. Riparian buffers can remove up to 90 percent of pollutants in certain landscapes when managed properly. Forested riparian buffers greatly increase the ability of headwater streams to remove nutrients, thereby providing an additional filter before nitrogen and phosphorus pollution can reach major rivers, lakes, and the Bay.

Transporting Excess Manure out of Manure Hot Spots

The most widely applied use for excess manure is to transport the manure to other regions that need fertilizer for their crops. Consequently most Bay states now help pay for the transport of manure out of manure hot spots. In order to transport all of the excess manure in the Chesapeake Bay watershed to areas that can use it as fertilizer, a USDA Economic Research Service report determined that 60 percent of all cropland in the watershed would need to utilize manure. Current data suggests that between 10 and 20 percent of cropland now receive manure. Transporting this amount of manure would have an overall cost estimated at about $150 million per year.

While transporting manure is an important component to addressing excess manure in the short term, there are numerous drawbacks that require that alternative uses of manure be developed for long term sustainability. Moving manure out of the hot spots will help reduce polluted runoff from those areas, but recent research indicates that it likely will increase nutrient pollution in the receiving areas unless adequate safeguards are implemented. Also, transported manure must be tracked closely and coordinated regionally to prevent manure from being moved from one hot spot to another. Additionally, many landowners are likely to refrain from accepting manure due to logistical, environmental, and financial reasons. Therefore, it is essential that alternative uses of manure that are economically and environmentally sustainable be developed immediately.

Alternative Uses of Excess Manure

Abandoned mine reclamation

The Chesapeake Bay states contain hundreds of thousands of acres of abandoned mine lands that support little or no vegetation. As a result, acid runoff from mine residues flows across these barren areas and into local streams. The nutrients contained in manure are of tremendous value in restoring vegetative cover in these areas when combined with lime applications to balance the soil's pH. High concentrations of phosphorous and potassium promote critical root growth that is essential for plant survival in these difficult environments. The higher concentrations of phosphorus in poultry manure are particularly useful. The organic matter contained in the manure is also an essential addition to the soil. As streams recover from acid mine drainage, they absorb more nutrients, becoming natural helpers in the effort to reduce nutrient pollution.

Energy production

Farmers often view manure as an asset because its nutrients can fertilize crops. However, manure also has value as an energy source. The energy value of the 14 million tons of recoverable manure generated in the Bay watershed each year is 70 trillion Btu, which is roughly equivalent to 2.6 million tons of coal or 400 million gallons of gasoline. With increasing energy costs and concerns of energy security facing the nation, there is new interest in bioenergy from manure and other agricultural materials. Bioenergy also has the potential to provide a major new industry and economic boost to rural America.

Numerous technologies produce energy from animal waste, and the methods are continually being refined to make them make them more efficient and profitable. Generally, manure can be converted to energy through four processes: combustion, pyrolysis, thermal gasification, and biogasification.

Combustion is the process of burning dry manure such as poultry litter to produce heat or steam to run a turbine. A British company has built four large poultry litter combustion plants in Europe and is in the process of commissioning one in Minnesota. Combustion technologies are the most developed and commercially available of the animal waste energy processes, but concerns remain about air emissions and energy prices compared to traditional sources.

Both pyrolysis and thermal gasification break down the manure into more concentrated products such as oils or hydrogen gas that have more concentrated energy content and therefore can be readily used as fuels. There are relatively few pyrolysis or thermal gasification plants in the United States. Most of them currently process wood wastes and have only utilized manure on an experimental basis.

Biogasification allows bacteria to breakdown liquid manures, such as dairy or hog waste, to produce methane as a fuel source. In 2001, there were 32 biogasfication operations in the United States, most of which utilize dairy waste to produce methane, which is captured as an energy source.

It is beyond the scope of the report to assess each of these processes and technologies, but each has been demonstrated successfully, and commercial scale examples exist in the United States, Europe, and Canada. Industry research suggests that new energy production facilities are becoming more economically feasible. However, air emissions are a potential drawback with some processes, particularly in areas such as the Shenandoah Valley and parts of Maryland where air pollution levels already violate federal clean air standards. These processes' waste products, such as ash, can also contain significant amounts of nutrients, but they are in a denser and more stable form than raw manure and could potentially be marketed as fertilizers.

Composting

Composting remains an effective way to stabilize manure nitrogen, thus minimizing nitrogen losses to the environment when the compost is used. A recent Rodale Institute study compared nitrogen losses from compost, raw manure, and conventional fertilizer, and found that only about 4 percent of the nitrogen applied as compost was lost, while about 9 percent was lost through the other two forms of fertilizer. Compost must still be carefully managed according to university recommendations, as leaching of nitrogen remains a possibility. In the composting process itself, nitrogen can be lost to the atmosphere or through runoff and leaching if compost piles are not managed properly. Though composting facilities sometimes trigger odor complaints, a well-managed composting operation does not cause odor problems. Composted manure can be used in a variety of farming, nursery, greenhouse, and landscaping operations, which can reduce the overall amount of nutrients imported into the Chesapeake Bay watershed. Additionally, composting can be used to suppress ammonia volatilization in poultry litter either by utilizing it in bedding material or as a filter for poultry house exhaust.

Pelletizing

Poultry manure may also be dried and pelletized to produce a fertilizer product that is more balanced and consistent in its nutrient content, as well as pathogen and odor-free. Two such plants have been initiated in the Chesapeake Bay watershed, Perdue AgriRecycle and Harmony Shenandoah Valley. To date these have been the only large-scale alternative uses of manure in the region. Each of them was designed to create a product using raw poultry litter that can be formulated to meet specific crop needs and includes beneficial micronutrients and organic matter. However both plants faced challenges in developing a market for their product, and questions remain about the fate of heavy metals and other additives found in poultry manure.

Perdue AgriRecycle has sold its pellets primarily to non-agricultural users such as golf courses and landscapers, and is producing about 50,000 to 60,000 tons of fertilizer per year. It is currently trying to expand into the retail fertilizer market and export more of its product outside the Bay watershed. Harmony Shenandoah Valley recently shut down its production, reportedly because of an inability to penetrate markets for its fertilizer and problems with an associated power generation facility. The experience of these two plants emphasizes the need to develop markets as well as technology for alternative uses of manure.

RECOMMENDATIONS: KEY ACTIONS THIS YEAR

Animal wastes have a significant impact on our water resources from small creeks and streams to major tributaries and the Bay, but there are actions that can and must be taken to reduce the pollution damaging water quality. There are solutions that are compatible with agriculture and that can improve the bottom line for farmers. Because of the many hidden costs associated with manure pollution, development of alternatives must be jump-started instead of waiting for markets to solve the problem.

Numerous state, federal, and private efforts are actively working to improve manure management and reduce polluted runoff. Substantial resources have been invested in manure storage and handling facilities, and nutrient management programs are stronger now than they have been in the past. In some areas, streamside buffer programs have increased protection for streams by fencing out livestock and filtering runoff. Additionally, the 2002 federal Farm Bill sharply increased funding for livestock related issues. CBF continues to support these integral programs and to forge partnerships to increase adoption and implementation. However, all the current programs are under-funded and insufficient to meet the needs of farmers. The demonstrated success on Green Run and the North Fork clearly show that much greater levels of support and commitment will be necessary for degraded local streams and the Bay to recover.

The following key actions must be taken this year across the watershed to better address pollution from agriculture.

- **Implement Tributary Strategies.** The tributary strategies contain numerous provisions to address nitrogen and phosphorus pollution from manure and agriculture in general. Despite a deadline for completion of April 2004, to date no specific plans or funding sources have been developed to actually implement these strategies. CBF calls on:

  - *The Chesapeake Bay Executive Council to complete implementation plans that include measurable annual benchmarks to insure progress along with necessary, funding mechanisms for the tributary strategies by December 2004.*

- **Fund the Chesapeake Bay federal Farm Bill proposal.** The 2002 federal Farm Bill significantly increased funding to reduce water pollution from farms. However, these programs have not been fully funded and fall far short of farmers' needs to achieve local and Bay water quality goals. In July 2002, the Bay states submitted a proposal to the federal Secretary of Agriculture for a $20 million per year Chesapeake Bay Working Lands Nutrient Reduction Pilot Program. Despite having the specific authority under the 2002 Farm Bill and direction from Congress, USDA has yet to implement this program. CBF calls on:

  - *The U.S. Department of Agriculture to fund the Chesapeake Bay Working Lands Nutrient Reduction Pilot Program at $20 million annually through 2007, the remainder of the current farm bill.*

- **Reduce the amount of nutrient pollutants in manure.** Some poultry growers have already changed the composition of their animals' feed, which subsequently has reduced manure phosphorous by 16 percent and potentially could cut it by up to 50 percent. Similar changes to feed can also be applied in hog operations. In addition, new research indicates that lower nutrient levels in dairy feed could reduce pollution from cow manure by up to 40 percent, while saving the region's dairy industry as much as $18 million a year. In Pennsylvania, which has two thirds of the region's dairy cows, CBF and the Pennsylvania Department of Agriculture will hold an October summit of farmers, feed producers, scientists, and government agencies to determine the most effective structure for the program. CBF calls on:

- *Pennsylvania's Governor and Legislature to establish a $10 million Dairy Feed Management pilot program to improve dairy feed efficiency as part of a larger agricultural funding initiative in the next legislative session.*

- *Each Bay state, upon completion of the Pennsylvania pilot program, to establish a similar program refined to meet the state's particular needs.*

- **Require safeguards when manure is spread on cropland.** Many available methods to increase the efficiency of manure fertilizer and reduce polluted runoff are not currently included in nutrient management plans and must be more widely adopted. CBF calls for:

  - *The Bay states to ensure that nutrient management programs include readily available safeguards against manure runoff.*

    - *Manure should be appropriately incorporated into the cropland to reduce air releases and surface runoff.*

    - *The timing and amount of manure applied should be closely tied to both the nitrogen and phosphorus needs of the crop.*

    - *Direct discharges of manure to surface waters should be prevented through the use of setbacks and vegetated buffers.*

    - *Cover crops should be encouraged through operational incentives as well as existing financial incentives.*

  - *Full implementation and enforcement of federal water quality permits for Concentrated Animal Feeding Operations (CAFO) to prevent manure runoff.*

- **Establish viable alternative uses for manure.** Since many fields where manure is traditionally applied are already saturated with nutrients, governments and industry should initiate and develop incentives for new technologies that show potential for innovative uses of manure. "Bioenergy" plants, which generate power from manure and other farm products, are already operating on a commercial scale in Europe and Canada and at some sites in the United States. Four different bioenergy processes already exist and are being refined. Manure can also help restore soil fertility on barren land left by mining operations. It is already being turned into compost and pelletized fertilizer, but appropriate markets for the material need to be expanded. Manure can and should be a valuable resource for farmers and can help stimulate rural economies. CBF calls on:

  - *Each Bay state, by June 2005, to prepare a strategy to develop sufficient alternative uses for all excess manure addressing technology, funding, marketing, and implementation needs.*

- *Maryland's Governor and the General Assembly to reinstate its Animal Waste Technology Fund and commit $5 million next year to initiate a competition among private enterprises for the most cost-effective, environmentally friendly alternative uses of manure.*

- *Maryland's Governor and General Assembly to develop a broad-based user fee, with contributions from businesses and consumers, dedicated to providing $25 million annually to ensure the availability of alternative uses and to help farmers implement other needed agricultural practices to address manure runoff.*

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