THE OHIO STATE UNIVERSITY EXTENSION

Extension FactSheet

AEX-444-04

Food, Agricultural and Biological Engineering, 590 Woody Hayes Drive, Columbus, OH 43210

A Basic Primer on Nonpoint Source Pollution and Impervious Surface

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For over three decades, research studies have sought to quantify the relationship between urbanization and the quality of water in our lakes, streams, and reservoirs. In general, studies have found that water quality decreases with increasing urbanization. More recent studies indicate that high levels of pollutants associated with stormwater runoff and an increase in impervious surfaces are the main causes of water quality degradation. Water quality impacts present major public health and economic concerns for local communities trying to provide adequate drinking water and recreational opportunities for increasing numbers of residents.

This fact sheet presents a basic description of nonpoint source pollution and impervious surface. It is intended to serve as an overview for the reader who already has a general understanding of water quality issues. This is the first of a series of publications on water quality, impervious surfaces, and natural resource based planning tools.

The authors would like to thank the National NEMO Program, Indiana Sea Grant program "Planning with Power," and Ohio State University Extension for their assistance in writing and reviewing the publications in this series.

What Is Nonpoint Source Pollution?

Nonpoint source (NPS) water pollution is the introduction of pollutants into a system through a non-direct or unidentified route. Agriculture and forestry practices, septic systems, recreational boating, urban runoff, construction, and physical changes to stream channels are all potential sources of NPS pollution. The term *nonpoint* is used to distinguish it from point source pollution, which comes from a specific source such as sewage treatment plants or industrial facilities. NPS pollution is often associated with rainfall or melted snow that runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and oceans. NPS pollution can occur just about anywhere, but especially where activities disturb the land or water, and where paved surfaces allow pollutants to flow directly into waterways.

While the most common NPS pollutants are sediments (dirt) and fertilizers from agricultural land, small and medium-sized animal feeding operations, construction sites, and other areas that have been disturbed, runoff from urban areas is becoming a major problem. Common NPS pollutants and their sources are included in Table 1.

Why Do We Care About NPS Pollution?

NPS pollution has been associated with water quality standard violations and the contamination of aquatic ecosystems that lead to unsafe drinking water, destroyed habitat, severe flooding, fish kills, property loss, and many other environmental and human health problems. According to the National Water Quality Inventory 1998 Report to Congress, 35% of the surveyed waters in the United States were affected by various water quality problems. Sediment, pathogens, and fertilizers were the pollutants most responsible for these water quality problems. Agriculture, physical changes to the stream, and urban runoff/storm sewers, all of which are nonpoint sources, were the leading sources of pollution (USEPA, 2000). NPS pollution affects all aspects of our environment, not only water resources. For example, a recent study of the economic impact of erosion on surface water systems estimates the annual costs for damages such as fish kills or increased pollutants in drinking water caused by erosion in North America to be approximately $16 billion (Osterkamp et al., 1998).

What Is Impervious Surface?

In urban areas impervious surface area is often associated with NPS pollution. Impervious surfaces are hard surfaces such as asphalt, concrete, rooftops, and highly compacted soils. Unlike *pervious* areas where soil and

Table 1. Major Nonpoint Source Pollutants and Their Sources (adapted from Leeds et al., 1992)

NPS Pollutants	*Sources*
Sediment	• Construction Sites • Mining Areas • Agricultural Lands • Logged Areas • Bank/Shore Erosion • Grazed Areas
Nutrients **(Fertilizers, Grease, Organic Matter)**	• Agricultural Lands • Nurseries, Orchards • Livestock Areas • Lawns, Forests • Petroleum Storage Areas • Landfills
Acids and Salts	• Irrigated Lands • Mining Areas • Urban Runoff, Roads, Parking Lots • Landfills
Heavy Metals **(Lead, Mercury, Zinc)**	• Mining Areas • Vehicle Emissions • Urban Runoff, Roads, Parking Lots • Landfills
Toxic Chemicals **(Pesticides, Organic, Inorganic Compounds)**	• Agricultural Lands • Nurseries, Orchards • Building Sites • Gardens, Lawns • Landfills
Pathogens **(Bacteria, Viruses)**	• Domestic Sewage • Livestock Waste • Landfills

vegetation absorb rainwater, *impervious surfaces* are areas that water cannot go through. Land cover that is impervious prevents rainwater from entering into the soil and forces it to run off the land until it finds a place where it can enter the soil or is incorporated into man-made drainage systems that carry it directly to a stream, lake, or estuary. In urban areas, land that once absorbed rainfall is now covered with buildings and pavement, thus more rainfall than ever is entering our drainage systems and local streams.

Why Should We Care About Impervious Surface?

Impervious cover is an unavoidable result of urban development. It makes more water flow over the land as runoff and starts a chain of events that begins with changes in the water cycle, impacts riparian areas, adds water pollution, and eventually decreases water quality. Figure 1 illustrates changes to the water cycle that occur as a result of increased imperviousness. In undeveloped areas, there is usually very little or no surface runoff during normal rainfall events. Water either seeps into the ground or is returned to the atmosphere by evaporation. As imperviousness increases, runoff increases and the ability of water to seep into the soil or evaporate decreases because it is moved off the land too quickly.

In many places, as little as 10% impervious cover has been linked to stream impacts, which increases in severity as impervious cover increases (Schueler, 1995). The amount of impervious cover in the watershed can be used as an indicator to predict how severe these impacts might be. Research has shown that as the amount of impervious surface increases, the amount of runoff generated increases. This leads to increased amounts of water flowing in the stream, especially during heavy rainfalls; less ground water flowing through the soil (base flow); and more erosion of the stream bed because of faster flowing water. These changes to stream flow result in flooding; habitat loss; erosion, which widens the stream channel; and physical changes in how the stream looks and functions. These impacts are summarized in Table 2.

The effects of urbanization on riparian habitat, and macroinvertebrate and fish communities can generally be classified into three categories: low, moderate, and high (USEPA, 1993). At low levels of urban development, the riparian zone has lots of vegetation and no erosion from the stream banks; there are lots of different species of fish and macroinvertebrates in the stream. At moderate levels of urban development, some of the riparian plants have been removed and there is some erosion of the stream banks; there is less of a variety of macroinvertebrate and fish species in the stream. At high levels of urban development, the riparian area is nearly gone and the stream banks are completely bare, which increases erosion of the stream banks; there are just a few different species of fish and macroinvertebrates in the stream because habitats within the stream were destroyed and the pollution intolerant species have either left or died.

Integrating Water Resource Protection into Community Planning

Protection of water quality in urbanized areas is difficult because of many factors. These factors include different amounts and types of pollutants entering the water, large amounts of runoff, limited areas suitable for surface water runoff treatment systems, high costs associated with structures to control runoff, and the destruction or absence of riparian zones that can filter pollutants and prevent erosion of stream banks and shorelines.

While dealing with impervious surfaces cannot solve all water related issues, it can be a simple and cost-effective indicator of water pollution and can often pro-

Table 2. Impacts from Increases in Impervious Surface Coverage (USEPA, 1997).

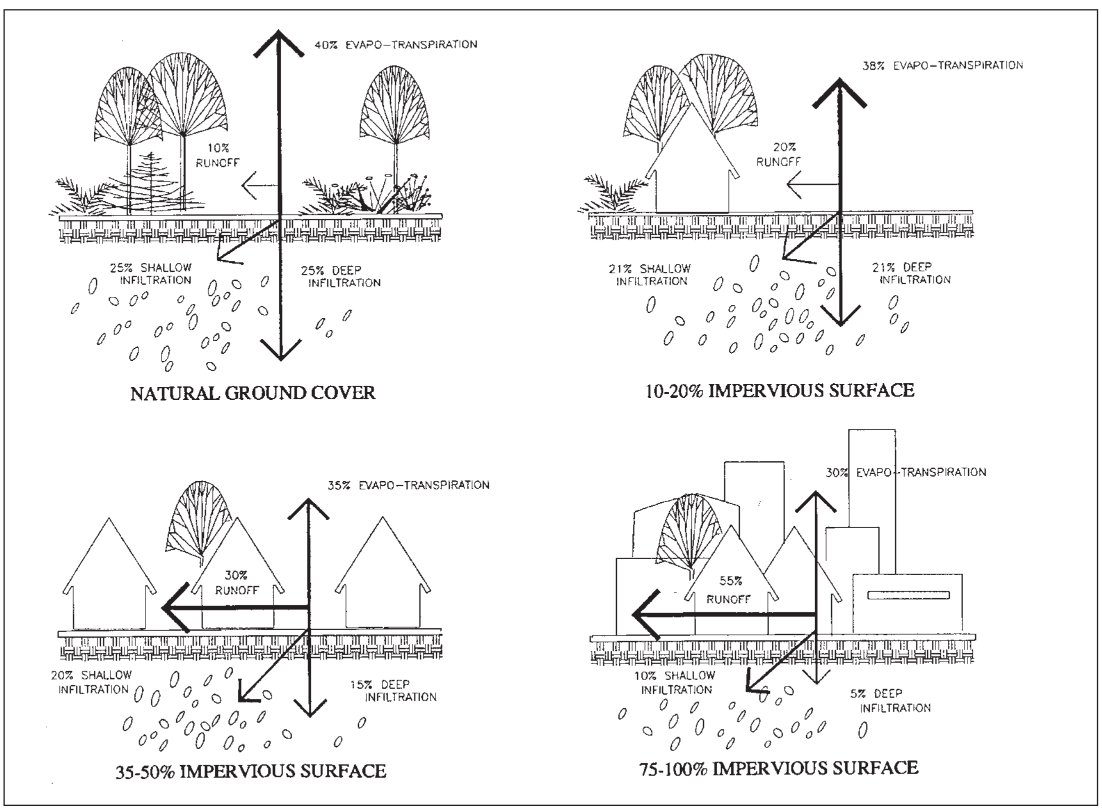
Increased Impervious Leads to:	Resulting Impacts				
	Flooding	Habitat Loss	Erosion	Channel Widening	Stream Alteration
Increased Amount of Flow	✓	✓	✓	✓	✓
Increased Peak Flow	✓	✓	✓	✓	✓
Increased Peak Duration	✓	✓	✓	✓	✓
Decreased Base Flow		✓			
Sediment Loading	✓	✓	✓	✓	✓

vide a solid foundation for a plan of action. The usefulness of managing impervious surfaces is twofold. First, research from the past 15 years consistently shows a strong link between the imperviousness within a watershed and the quality of its water. Second, impervious surface is an easily identified, measurable aspect of the landscape. Making the connection between impervious surface and water pollution often allows local officials to better see how protection of water resources relates to other issues such as road widths, curbing, landscaping requirements for commercial zones, etc.

Water resource protection can be more easily included into planning concepts such as performance zoning, residential design, and open space subdivisions by linking them to imperviousness in an effort to reduce the amount of paved surfaces. While providing "greener" development, these planning concepts can also reduce the social, economic, developmental, and environmental costs of urbanization.

Framing the issue of NPS pollution in terms of impervious surface can be an effective way of enabling local decision-makers to understand and take action on this and other water resource-related issues such as flooding. With impervious surface as a foundation, planning that begins with water resources often leads to character, design, and aesthetic issues that, taken together, define much of the overall quality of life in a community. For more information on integrating water resources into community planning, please refer to the second fact sheet in this series, "Natural Resource Based Planning: An Overview of Strategies to Deal with Polluted Runoff and Imperviousness."

Figure 1. Water cycle changes associated with urbanization (after Tourbier and Westmacott, 1981).



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