IMPACTS OF DEVELOPMENT ON WATERWAYS

Key Finding

Standard land development can drastically alter waterways. Increase stormwater runoff associated with development often begins a chain of events that includes flooding, erosion, stream channel alteration and ecological damage. Combined with an increase in man-made pollutants, these changes in waterway form and function result in degraded systems no longer capable of providing good drainage, healthy habitat or natural pollutant processing. Local officials interested in protecting municipal waters must go beyond standard flood and erosion control practices and address the issue of polluted runoff through a multilevel strategy of planning, site design and stormwater treatment.

Disruption of the Water Cycle

When development occurs, the resultant alteration to the land can lead to dramatic changes to the hydrology, or the way water is transported and stored. Impervious man-made surfaces (asphalt, concrete, rooftops) and compacted earth associated with development create a barrier to the percolation of rainfall into the soil, increasing surface runoff and decreasing groundwater infiltration (Figure 1). This disruption of the natural water cycle leads to a number of changes, including:

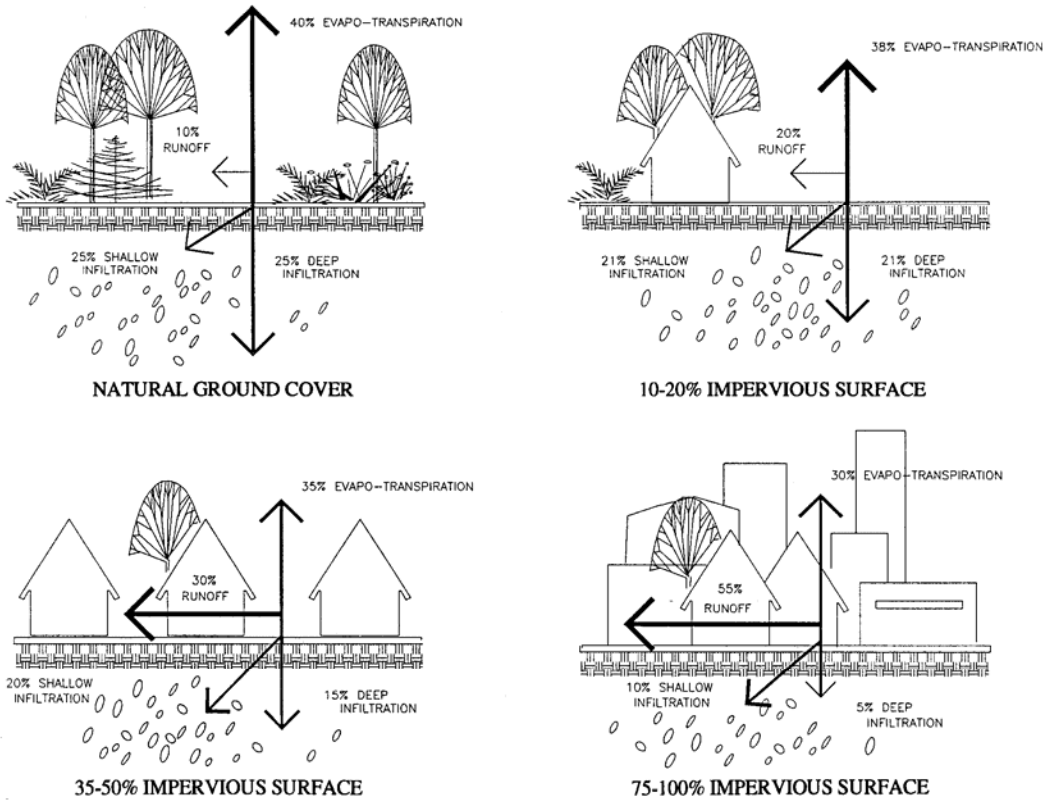

Figure 1. Water cycle changes associated with urbanization (after Tourbier and Westmacott, 1981).

Nonpoint Education for Municipal Officials (NEMO) is an educational program for land use decision makers that addresses the relationship of land use to natural resource protection.

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- increased volume and velocity of runoff;
- increased frequency and severity of flooding;
- peak (storm) flows many times greater than in natural basins;
- loss of natural runoff storage capacity in vegetation, wetland and soil;
- reduced groundwater recharge; and
- decreased base flow, the groundwater contribution to stream flow. (This can result in streams becoming intermittent or dry, and also affects water temperature.)

Hy•drolo•ogy:
A science dealing with the properties, distribution and circulation of water.

Ri•par•i•an:
Of or related to or living or located on the bank of a watercourse.

Hab•i•tat:
The place where a plant or animal species naturally lives and grows.

Impacts on Stream Form and Function

Impacts associated with development typically go well beyond flooding. The greater volume and intensity of runoff leads to increased erosion from construction sites, downstream areas and stream banks. Because a stream's shape evolves over time in response to the water and sediment loads that it receives, development-generated runoff and sediment cause significant changes in stream form. To facilitate increased flow, streams in urbanized areas tend to become deeper and straighter than wooded streams, and as they become clogged with eroded sediment, the ecologically important "pool and riffle" pattern of the stream bed is usually destroyed (Figure 2).

These readily apparent physical changes result in less easily discerned damage to the ecological function of the stream. Bank erosion and sever flooding destroy valuable streamside, or riparian, habitat. Loss of tree cover leads to greater water temperature fluctuations, making the water warmer in the summer and colder in the winter. Most importantly, there is substantial loss of aquatic habitat as the varied natural streambed of pebbles, rock ledges and deep pools is covered by a uniform blanket of eroded sand and silt.

Figure 2. Changes in stream form associated with urbanization.

All of this of course assumes that the streams are left to adjust on their own. However, as urbanization increases, physical alterations like stream diversion, channelization, damming and piping become common. As these disturbances increase, so do the

ecological impacts—the endpoint being a biologically sterile stream completely encased in underground concrete pipes. In addition, related habitats like ponds and wetlands may be damages or eliminated by grading and filling activities.

Then There's Water Quality

With development comes more intensive land use and a related increase in the generation of pollutants. Increased runoff serves to transport these pollutants directly into waterways, creating nonpoint source pollution, or polluted runoff. Polluted runoff is now widely recognized by environmental scientists and regulators as the single largest threat to water quality in the United States. The major pollutants of concern are pathogens (disease-causing microorganisms), nutrients, toxic contaminants and debris. Sediment is also a major nonpoint source pollutant, both for its effects on aquatic ecology (see above), and because of the fact that many of the other pollutants tend to adhere to eroded soil particles. NEMO Fact Sheet #2 provides more detail on polluted runoff and its effects.

The Total Picture: A System Changed for the Worse

The hydrologic, physical and ecological changes caused by development can have a dramatic impact on the natural function of our waterways. When increased pollution is added, the combination can be devastating. In fact, many studies are finding a direct relationship between the intensity of development in an area—as indicated by the amount of impervious surfaces—and the degree of degradation of its streams (Figure 3). These studies suggest that aquatic biological systems begin to degrade at impervious levels of 12% to 15%, or at even lower levels for particularly sensitive streams. As the percentage of imperviousness climbs above these levels, degradation tends to increase accordingly.

The end result is a system changed for the worse. Properly working water systems provide drainage, aquatic habitat and a degree of pollutant removal through natural processing. Let's look at those functions in an urbanized watershed where no remedial action has been taken:

Drainage: Increased runoff leads to flooding. Drainage systems that pipe water off-site often improve that particular locale at the expense of moving flooding (and erosion) problems downstream. Overall system-wide water drainage and storage capacity is impaired.

Habitat: Outright destruction, physical alteration, pollution and wide fluctuations in water conditions (levels, clarity, temperature) all combine to degrade habitat and reduce the diversity and abundance of aquatic riparian organisms. In addition, waterway obstructions like bridge abutment, pipes and dams create barriers to migration.

Pollutant removal: Greater pollutant loads in the urban environment serve to decrease the effectiveness of natural processing. Damage to bank, streams and wetland vegetation further reduces their ability to naturally process pollutants. Finally, the greater volume and irregular, "flashy" pulses of water caused by stormwater runoff impair natural processing by decreasing the time that water is in the system.

What Municipalities Can Do

Flood and erosion control have long been part of the municipal land use regulatory process, and are usually addressed with engineered systems designed to pipe drainage off-site as quickly and efficiently as possible. Flooding and erosion, however, are only two of the more easily recognized components of the overall impact of development on waterways. Standard drainage "solutions" address neither the root cause of these symptoms—increased runoff due to the way we develop land—nor the resultant environmental effects.

To begin to truly address the impacts of development, municipal officials need to look at their waterways as an interconnected system and recognize the fundamental changes that development brings to the water cycle, stream form and function, aquatic ecology and water quality. Incorporating this understanding into local land use decisions can help to guide appropriate development. There are a number of options that can be employed to reduce the impacts of development on water quantity and quality. Preventing such impacts in the first place is the most effective (and cost effective) approach and should always be emphasized. To this end, municipal officials should consider a three-tiered strategy of natural resource based planning, appropriate site design and use of best management practices (stormwater treatment). NEMO Fact Sheet #4 goes into this strategy in more detail.

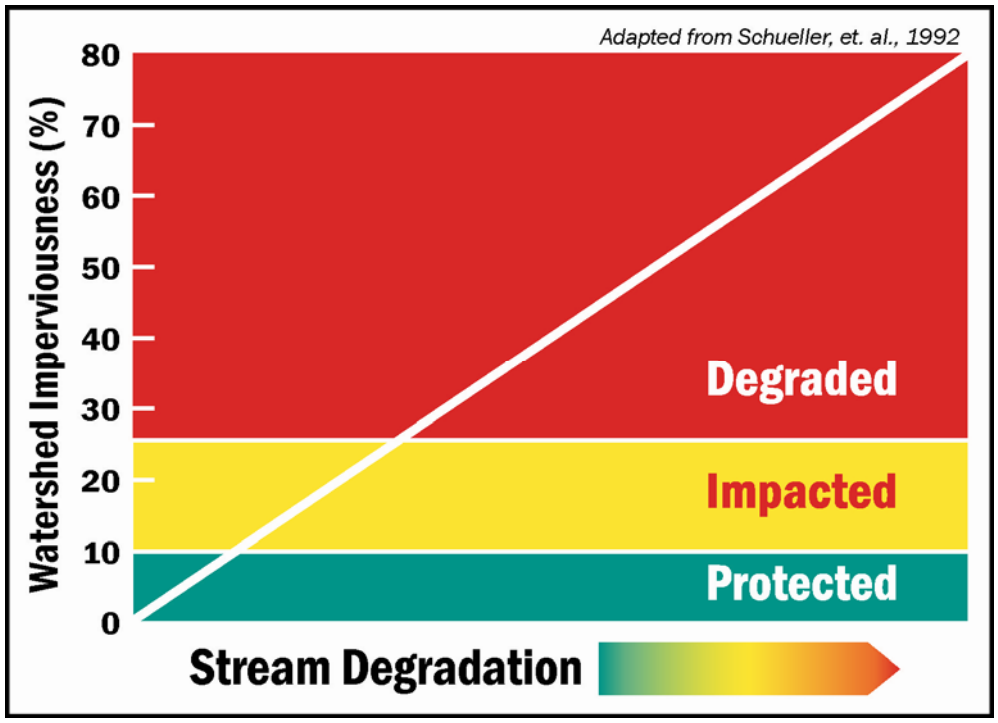

Figure 3. Stylized relationship between watershed imperviousness and receiving stream impacts.

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