NEMO NEVADA

"Protecting water quality through community planning"

Nonpoint Education for Municipal Officials

Fact Sheet-04-45

Impacts of Development on Waterways

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Traditional land development techniques can drastically alter waterways. Increased storm water 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, function, and chemistry can result in degraded systems no longer capable of providing good drainage, healthy habitat or natural pollutant processing. Local officials interested in protecting area 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 storm water best management practices.

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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 infiltration of rainfall into the soil. This increases surface runoff and decreases groundwater recharge (Figure 1, page 2). This disruption of the natural water cycle leads to a number of changes, including:

- increased volume and velocity of surface 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, wetlands and soil;
- decrease in water quality in tributary streams, which can result in reduced dilution of receiving waters;
- reduced groundwater recharge; and
- decreased *base flow*, the groundwater contribution to stream flow. This can result in streams flowing only intermittently or going dry. It can also affect water temperature or thermal pollution.

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

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deeper and straighter than wooded streams. As they become clogged with eroded sediment, the ecologically important "pool and riffle" pattern of the streambed is usually destroyed.

These visible physical changes result in less easily discerned damage to the ecological function of the stream. Bank erosion and severe flooding destroy valuable stream side, or *riparian*, habitat. Loss of tree cover often 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.

All of this, of course, assumes that the streams are left to adjust on their own. However, as urbanization increases, physical alterations, such as stream diversion, channelization, damming and piping, become common (Figure 2, page 3). Additionally, continued development encroaches on the upper watershed areas, polluting tributary streams. Normally, flows from tributaries serve to dilute the downstream receiving waters, thus diluting pollution levels. However, when tributaries become polluted, they no longer dilute the pollution levels in receiving waters. Rather, they add pollutants to the receiving waters. As these disturbances increase, so do the ecological impacts. We are often left with a biologically sterile stream completely encased in underground concrete pipes. In addition, related habitats, such as ponds and wetlands, may be damaged or eliminated by grading and filling activities.

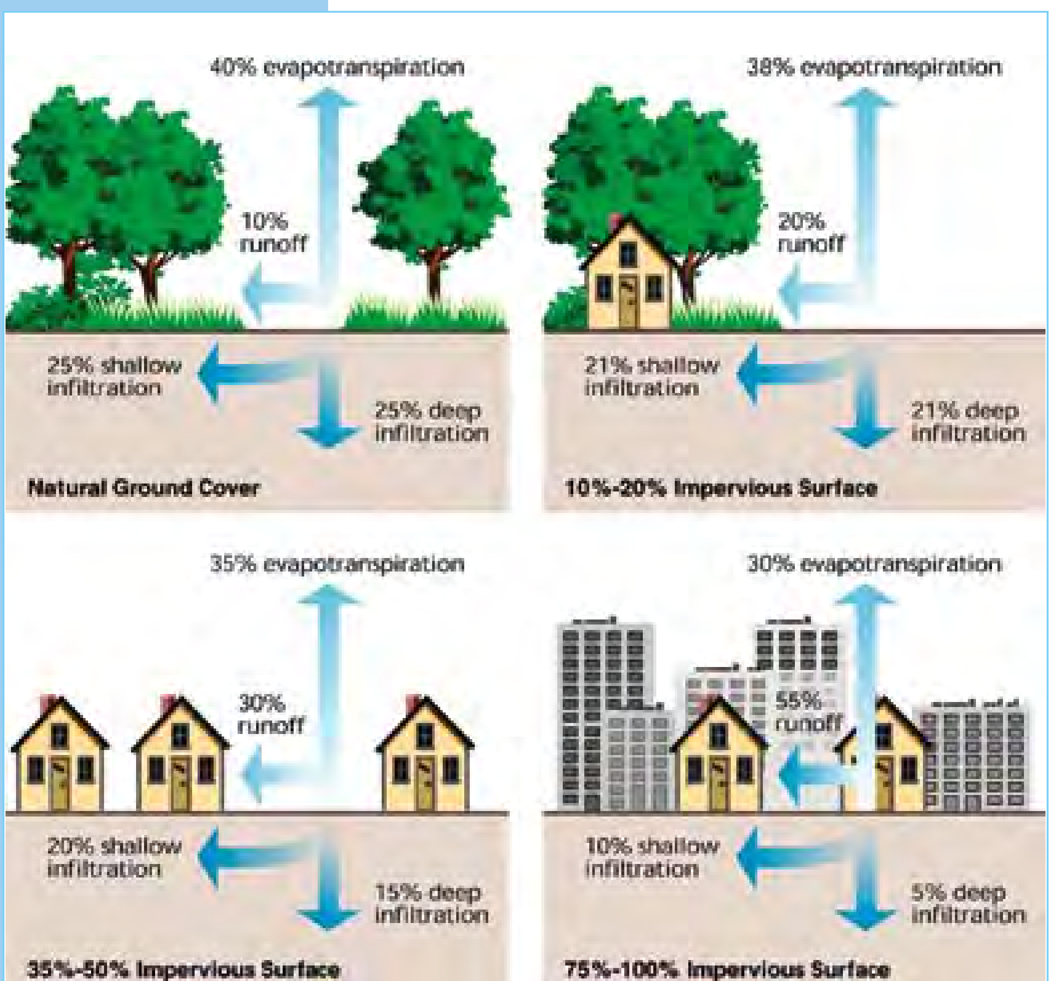

Figure 1. As the amount of impervious surface increases, runoff increases and infiltration of water decreases. (From Stream Corridor Restoration, FISWRG, 1998.)

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. It impacts aquatic ecology, and many pollutants tend to adhere to it.

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 have found 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, page 4). These studies suggest that aquatic biological systems begin to degrade at impervious surface levels of 12 percent to 15 percent, or at even lower levels for particularly sensitive streams. As the percentage of impervious surfaces increases, 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 systemwide water drainage and storage capacity is impaired.

HABITAT

Outright destruction, physical alteration, pollution and wide fluctuations in water conditions (levels, clarity, erodibility, temperature) all combine to degrade habitat and reduce the diversity and abundance of aquatic riparian organisms. In addition, waterway obstructions, such as bridge abutments, pipes and dams, create barriers to migration of fish and other wildlife.

POLLUTANT REMOVAL

Greater pollutant loads in the urban environment serve to decrease the effectiveness of natural processing. Natural processing refers to the ability of undisturbed water systems (wetlands, riparian areas, vegetated stream banks, etc.) and soils to perform many useful functions. These functions include retaining water, adsorbing nutrients, absorbing other pollutants, slowing or reducing surface runoff and aiding in infiltration of storm water. Damage to banks, streams and wetland vegetation reduces this ability to naturally process pollutants. Paving and soil compaction further reduce natural processing by reducing water infiltration and adsorption of nutrients and pollutants. Finally, the greater volume and irregular, "flashy" pulses of water caused by storm water runoff impair natural processing by decreasing the amount of time that water is in the system.

What Communities 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

Hydrology

A science dealing with the properties, distribution and circulation of water.

Riparian

Habitat located in the transition areas between the water surface along a stream or lake and the upland habitats.

Baseflow

That portion of stream flow derived from groundwater seeping into the stream.

Photo by S. Donaldson

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Figure 2. As areas urbanize, streams are often channelized and even forced into concrete ditches, destroying water quality and stream functionality.

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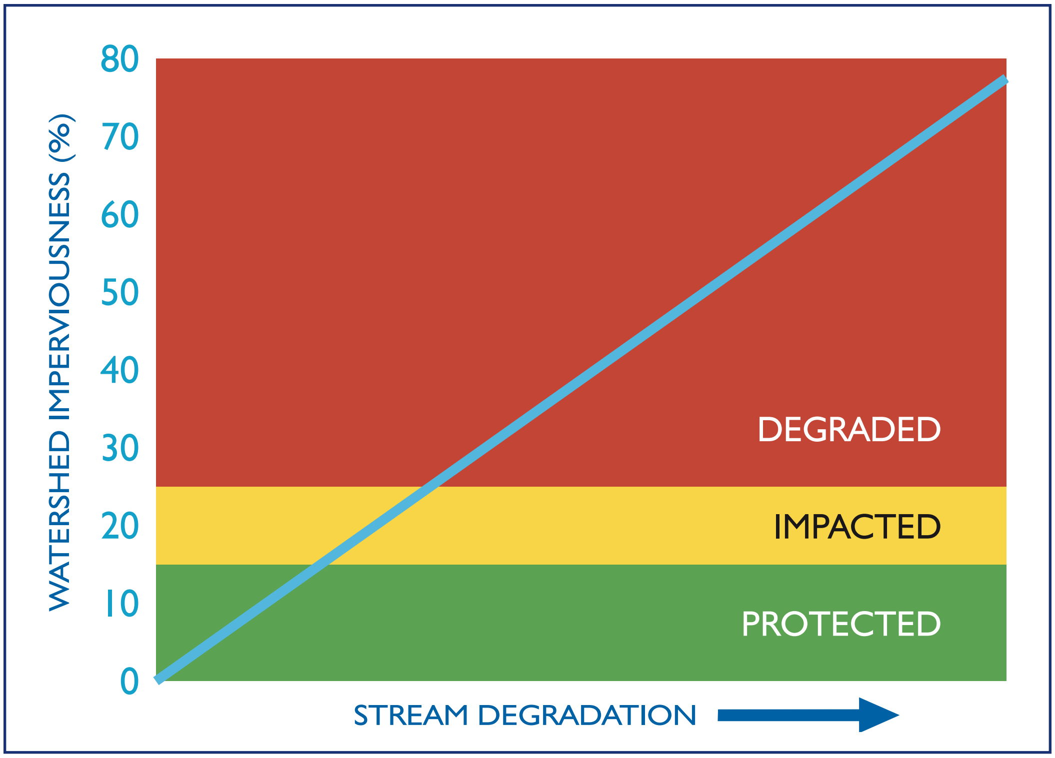

Figure 3. Stylized relationship between watershed imperviousness and receiving stream impacts (adapted from Schueler, 1992).

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, decision makers need to look at their waterways as an interconnected system. They must 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. A number of options 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.

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To this end, town officials should consider a three-tiered strategy of natural resource based planning, appropriate site design and storm water best management practices. NEMO Nevada Fact Sheet, "Strategies for Coping With Polluted Runoff," discusses this strategy in more detail.

References:

Federal Interagency Stream Restoration Working Group. 1998. Stream Corridor Restoration.

Schueler, T. 1992. Mitigating the Adverse Impacts of Urbanization on Streams: A Comprehensive Strategy for Local Government. In Watershed Restoration Sourcebook. Publication #92701 of the Metropolitan Washington Council of Governments. P. Kimble and T Schueler, editors.