IMPACTS OF DEVELOPMENT ON WATERWAYS

California Coastal Commission
Mission Resource Conservation District
State Water Resources Control Board
Local Government Commission
Department of Water Resources
National Oceanic and Atmospheric Administration
UC and USC Sea Grant

Key Finding

Standard land development can drastically alter waterways. Increased stormwater runoff associated with urban growth 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 community 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.

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Disruption of the Water Cycle

Linking Land Use to Water Quality

When urban growth occurs, resultant alterations to the land can lead to dramatic changes to the local *hydrology* (the way water is transported and stored). Impervious man-made surfaces (such as asphalt, concrete, and rooftops) and compacted earth associated with urbanization create a barrier to rainfall, which would otherwise percolate into and through the soil. Impervious surfaces also increase surface runoff, as well as decrease infiltration and groundwater recharge (Figure 1). This disruption of the natural cycle of water flow and infiltration leads to a number of harmful changes, including:

- 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, wetlands and soil;
- reduced groundwater recharge; and
- decreased *base flow* (the groundwater contribution to stream flow), which can result in streams becoming intermittent or dry, and also affect water temperature.

Impacts on Stream Form and Function

Impacts associated with urban growth 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, runoff and sediment generated by urban growth cause significant changes in stream form. To accommodate increased flow, streams in urbanized areas tend to become deeper and straighter than natural streams. As urban streams become clogged with debris and eroded sediment, the natural flow and pattern of the stream bed is altered, causing ecological damage and increased flooding (Figure 2).

These readily apparent physical changes result in less easily discernable damage to the ecological function of the stream. Bank erosion and severe flooding destroy valuable streamside, or

The California NEMO Partnership is an educational program for land use decision makers that addresses the relationship of land use to natural resource protection.

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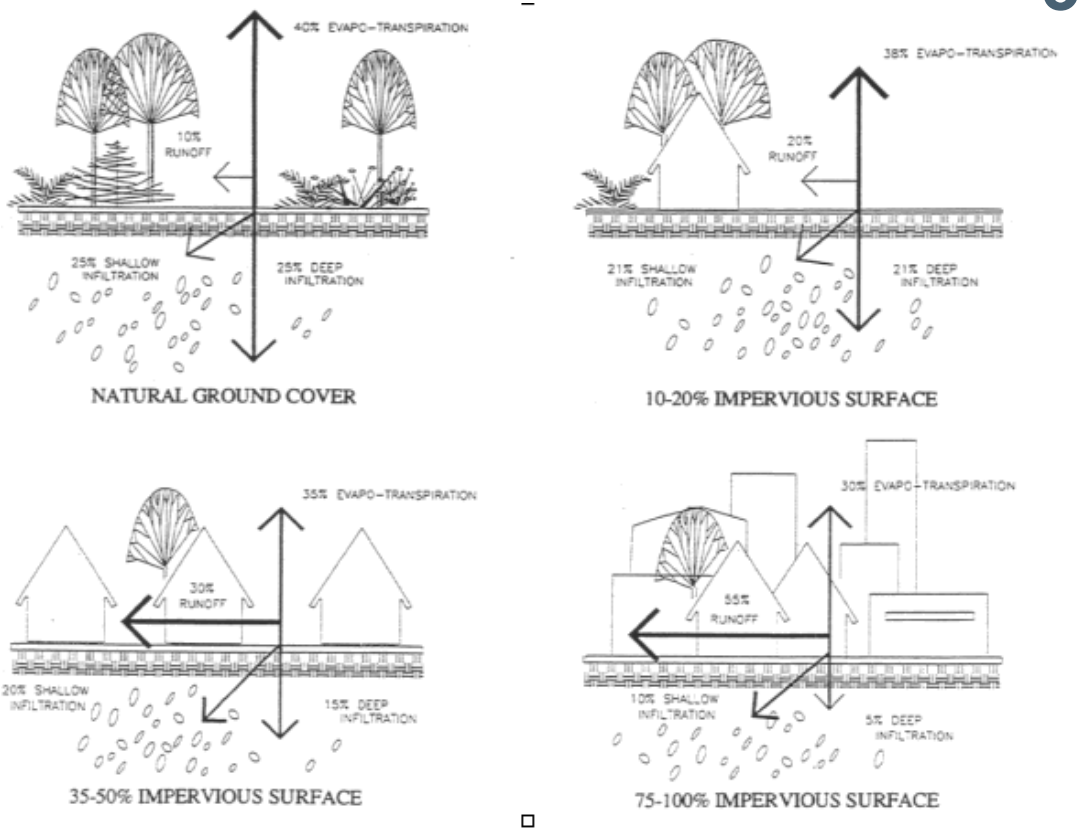

Figure 1. Water cycle changes associated with urbanization (after Toubier and Westmacott, 1981).

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 sediment.

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 does the ecological damage – the endpoint being a lifeless stream completely encased in concrete channels and underground pipes. In addition, associated habitats like ponds and wetlands may be damaged or eliminated by grading and filling activities.

Then There's Water Quality

With urban growth 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 *polluted runoff (nonpoint source pollution)*. 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 because of its effects on aquatic ecology (see above), and because

many other pollutants tend to adhere to eroded soil particles. CA NEMO Fact Sheet #2 provides more detail on polluted runoff and its effects.

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

Figure 2. Changes in stream form associated with urbanization

Linking Land Use to Water Quality

The Total Picture: A System Changed for the Worse

The hydrologic, physical, and ecological changes caused by urbanization 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 growth in an area – as indicated by the percentage 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:

Habitat: Outright destruction and physical alteration of steams, increased pollution, and wide fluctuations in water quality conditions (such as volume, clarity, and temperature) all combine to degrade habitat and thus reduce the numbers and types of aquatic and riparian organisms. In addition, waterway obstructions like bridge abutments, pipes, and dams create barriers to wildlife migration.

Pollutant removal: Greater pollutant loads in the urban environment may overwhelm the ability of natural processes to remove pollutants. Damage to river banks, streams, and wetland vegetation further reduces their ability to naturally remove pollutants. Finally, the greater volume and irregular ("flashy") pulses of water caused by storm events impair natural pollutant removal processes

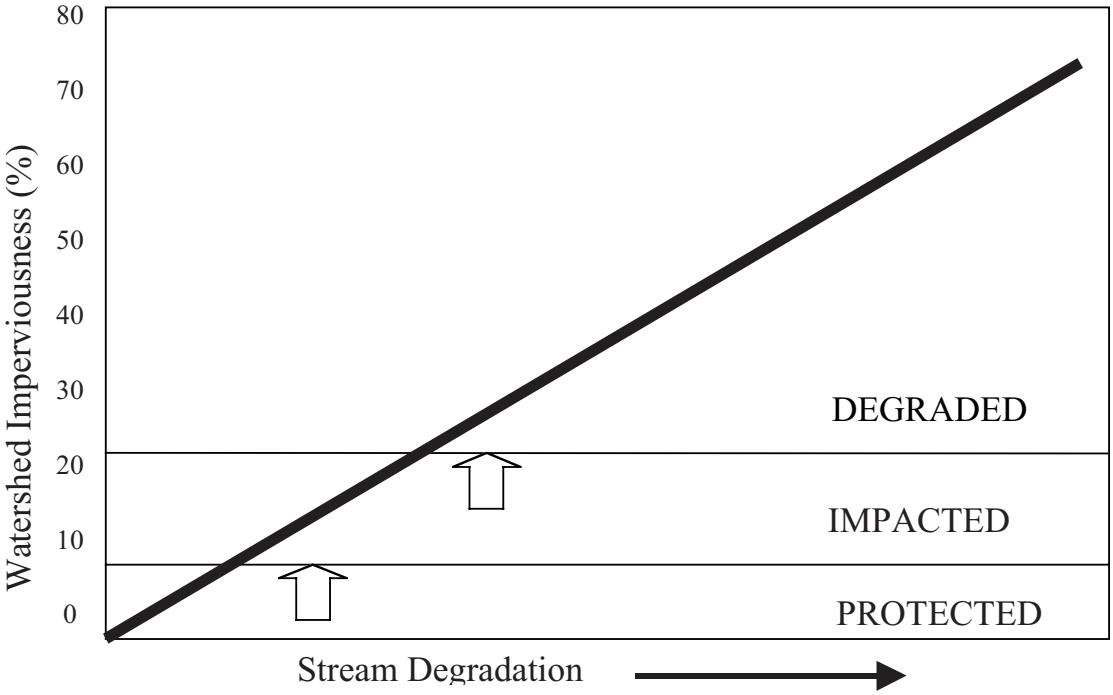

Figure 3. Stylized relationship between watershed imperviousness and receiving stream impacts (adapted from Schueler, 1992).

by decreasing the 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 the more easily recognized components of the overall impact of urban growth 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 urban growth, local officials need to look at their waterways as a valuable community resource as well as an interconnected water conveyance system. They also need to recognize the fundamental changes that development can bring to the water cycle, stream form and function, aquatic ecology, and water quality. Incorporating this understanding into local land use decisions will help to guide environmentally safe growth. 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 efficient) approach, and should always be emphasized. To this end, municipal officials should consider a three-tiered strategy consisting of natural resource based planning, appropriate site design, and stormwater treatment.