Land Use and Water Quality

Background: Our land-use decisions can have significant impacts on water quality (Figure 1). In specific, development decisions can lead to more intensive land use in our watersheds. Intensity of land use can be categorized as low intensity (e.g. open space including forested lands, shrub/grasslands, agricultural land, and managed green space) or high intensity (e.g. residential, commercial, and industrial).

When development occurs, the resulting alteration of the land leads to changes in the way water is transported and stored. Impervious surfaces (e.g. driveways, roads, sidewalks, rooftops, etc.) and compacted earth associated with development create a barrier to the infiltration of rainfall and snowmelt. This results in:

- decreased water quality;
- 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;
- decreased base flow (the groundwater contribution to stream flow).

Figure 1: Intensity of Land Use Results in Increased Impervious Surface and Potential Water Quality Problems.

Land Use and Stream Form: Impacts associated with development go 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 vegetated 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).

Figure 2: Natural Stream versus an Urbanized Stream

These apparent physical changes result in less easily recognizable damage to the ecological function of the stream. Bank erosion and severe 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 are 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 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 damaged or eliminated by grading and filling activities.

Land Use and Water Quality: Development often leads to 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, debris, and sediment (See Pennsylvania Lake Erie NEMO *Nonpoint Source Pollution* fact sheet for more information regarding the impact of polluted runoff on water quality).

The Big Picture: 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. 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 percent, 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.

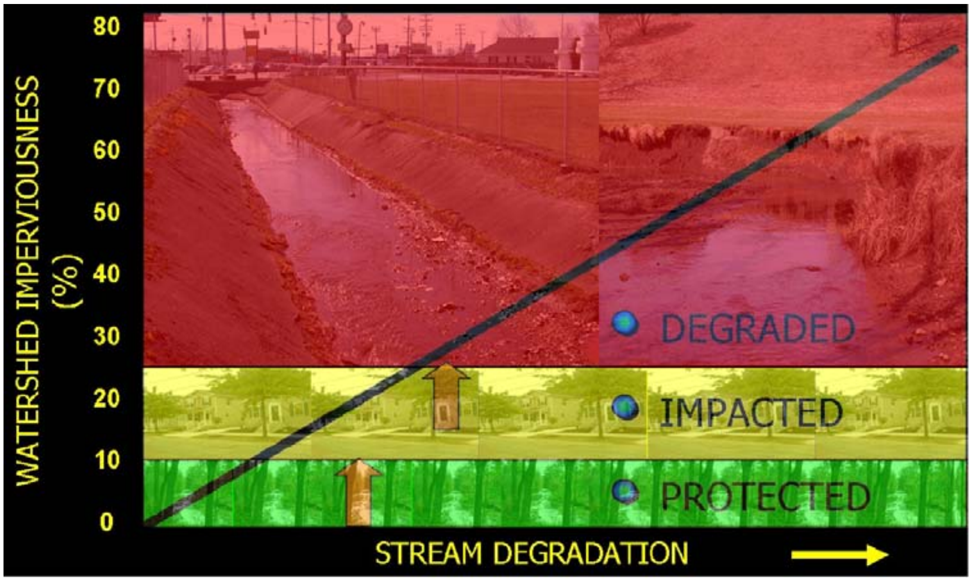

Figure 3: Stream Degradation Increases as Percent Impervious Surface Increases

Properly working water systems provide drainage, aquatic habitat, and a degree of pollutant removal through natural processing. These functions are altered in an urbanized watershed where no remedial action takes place.

> *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.
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> *Habitat:* Outright destruction, physical alteration, pollution, and wide fluctuations in water conditions (levels, clarity, and temperature) all combine to degrade habitat and reduce the diversity and abundance of aquatic riparian organisms. In addition, waterway obstructions like bridge abutments, pipes, and dams create barriers to migration for fish populations.
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> *Pollutant removal:* Greater pollutant loads in the urban environment serve to decrease the effectiveness of natural processing. Damage to bank, stream, and wetland vegetation further reduces their ability to naturally process pollutants. Finally, the greater volume and irregular, "flashy" pulses of water caused by storm water runoff impair natural processing by decreasing the time that water is in the system.

What Can Your Municipality 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 should look at 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, town officials should consider a three-tiered strategy of natural-resource-based planning, appropriate site design, and storm water treatment (i.e. best management practices).

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