How Urbanization Affects the Water Cycle

NEMO CALIFORNIA PARTNERSHIP

An educational program for land use decision makers that addresses the relationship of land use to natural resource

Why is the Water Cycle

Impervious Cover (IC)

Hard surfaces such as rooftops, driveways, streets, swimming pools, and

The ***water cycle*** is the continuous exchange of water between the land, waterways, and atmosphere. Under normal conditions, the water cycle works as a natural recycling system, constantly replenishing the earth's supply of water. Impervious cover associated with urbanization disrupts this process, resulting in degraded freshwater, estuarine, and marine ecosystems. Increased stormwater surface runoff associated with development is the first visible sign of water cycle alteration, and often initiates a chain of events that includes increased flooding, erosion, stream channel alteration, and ecological damage. This fact sheet reviews key concepts regarding the water cycle, how urbanization affects it, and the consequences of these changes.

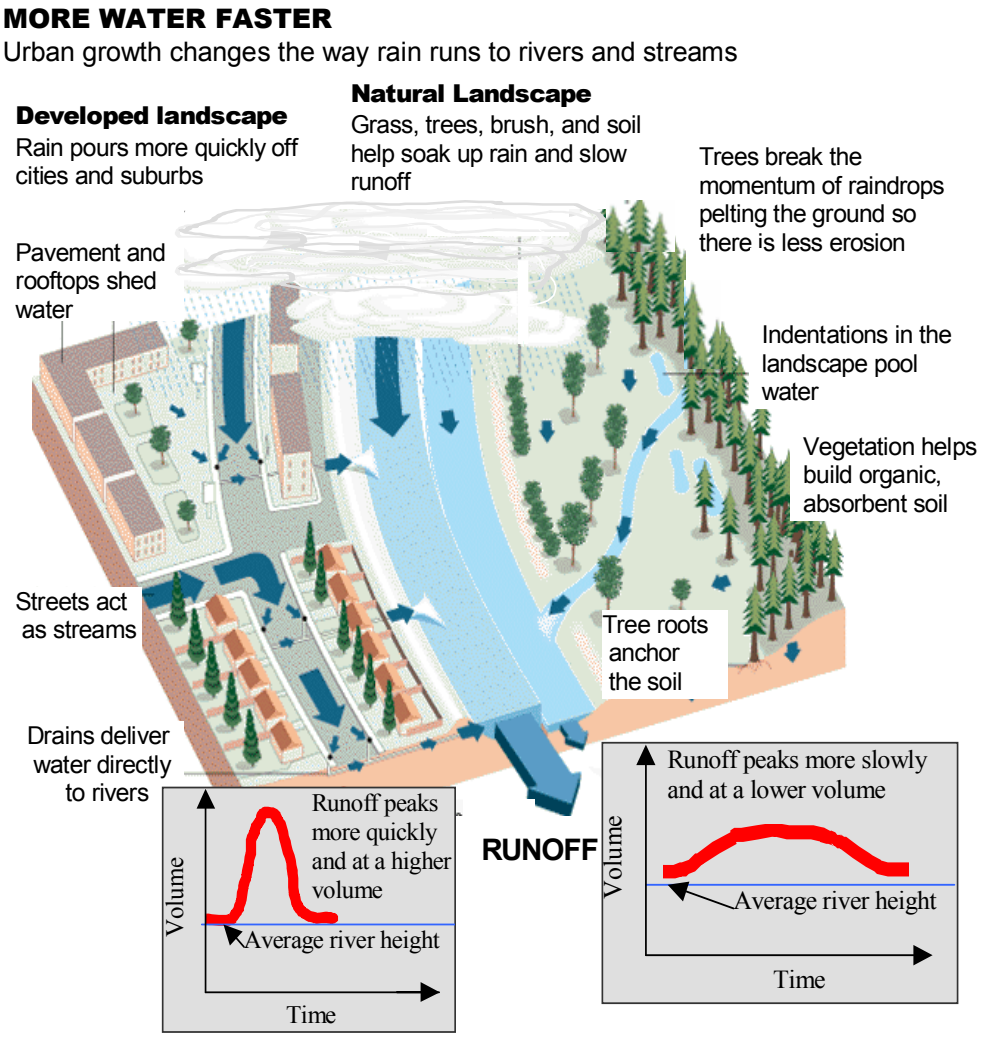
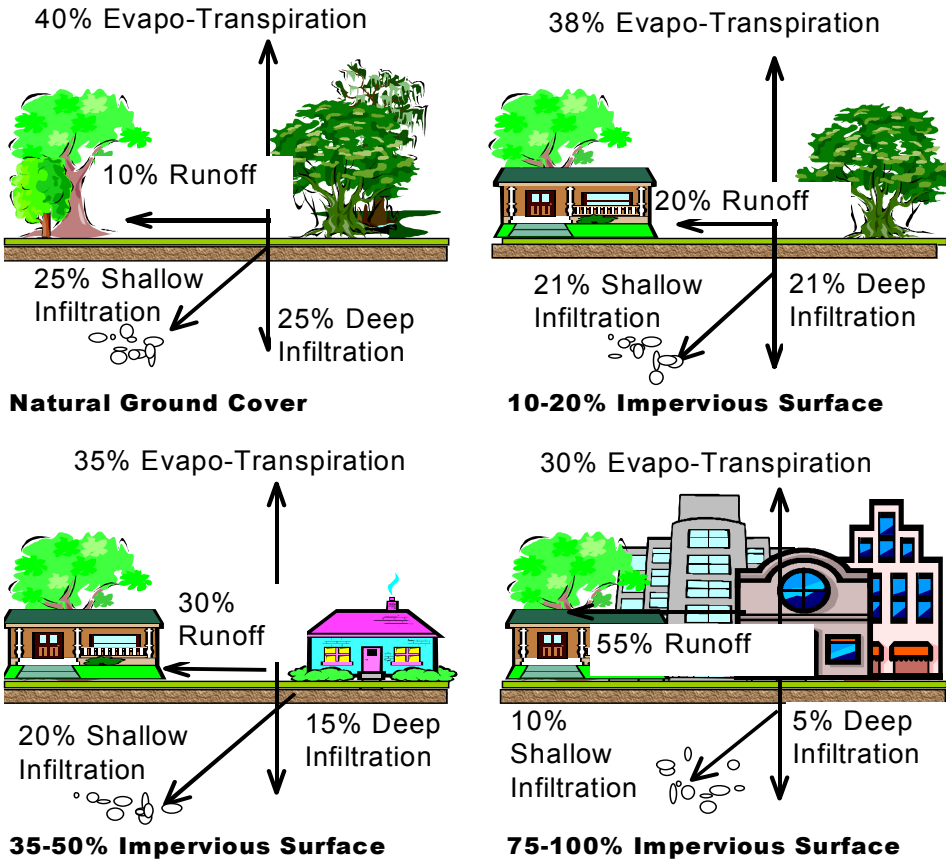


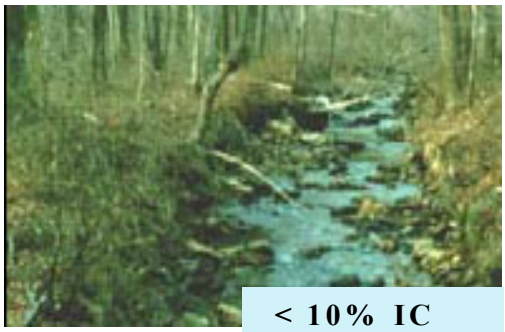
Figure 1 illustrates how IC and urban drainage systems transport increased runoff into receiving streams and rivers. The larger volume and velocity of water acts like a pressure washer on stream banks, making them more prone to erosion and causing habitat damage. Increased sediment loads from the land and eroding banks also clog stream channels and reduce the streams ability to transport the increased flow. Peak flows from watersheds with high percent IC occur more quickly and at a higher volume than rural streams, leading to more frequent floods.

Graphic research by Bee staff writers Nancy Vogel and Tom Knudson
Bee graphic/Scott Flodin

Figure 2. How impervious cover affects the water cycle

With natural groundcover, 25% of rain infiltrates into the aquifer and only 10% ends up as runoff. As imperviousness increases, less water infiltrates and more and more runs off. In highly urbanized areas, over one-half of all rain becomes surface runoff, and deep infiltration is only a fraction of what it was naturally.





< 10% IC

> 10% IC

Figure 3. Relationship between imperviousness and receiving stream quality.

In most cases, when the percent IC is less than 10%, streams remain protected. Above 10% IC, common signs of degradation are evident, which include bank erosion, loss of vegetative cover, and sedimentation.

- ✓ Reduced groundwater recharge
- ✓ Increased size and frequency of 1-2 year floods
- ✓ Decreased baseflow (movement of groundwater to surface water)
- ✓ Loss of streambank tree cover
- ✓ Increased fine sediment in stream bed
- ✓ Overall degradation of the aquatic habitat

Resources on the Web

Center for Watershed Protection
www.cwp.org

State Water Resources Control Board
www.waterboards.ca.gov.

NEMO National Network
http://nemo.uconn.edu/national/

Low Impact Development Center
http://www.lowimpactdevelopment.org/

EPA information on hydro cycle
www.epa.gov/seahome/groundwater/src/cycle.htm

The Stormwater Manager's Resource Center
www.stormwatercenter.net

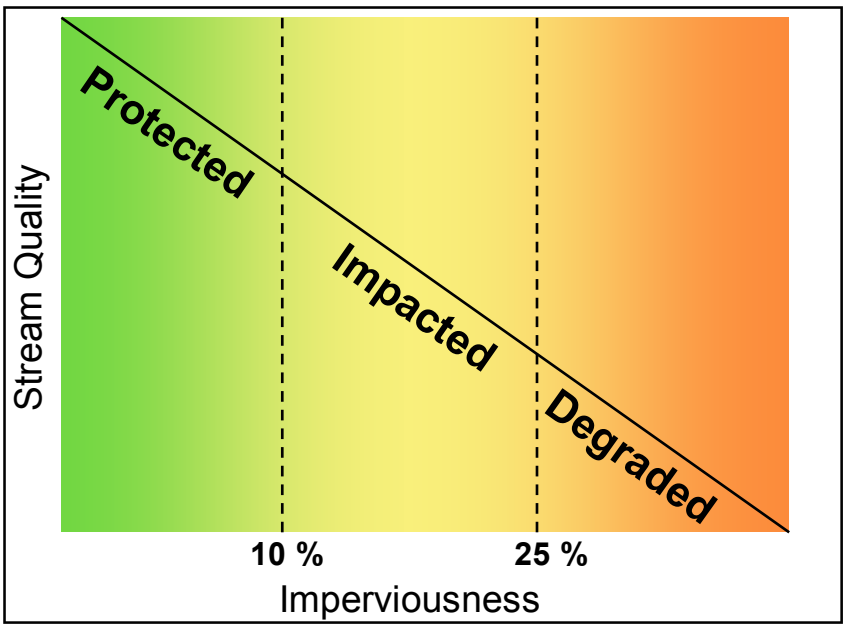


Figure 3. Stylized relationship between IC and stream habitat quality.

Between 10 – 25% IC, major alterations in stream morphology occur that significantly reduce habitat quality. At greater than 25% IC, streams suffer from loss of habitat, floodplain connectivity, and bank stability. (1)

California Case Studies

Studies on urban streams across California have consistently found similar patterns of degradation. For example, in Los Penasquitos Creek in San Diego County, watershed development grew from 9% to 37% urbanization between 1966-2000. From 1973-2000, the total annual urban runoff in the upper watershed increased by 4% per year, and the total dry-season runoff increased at an average rate of 13% per year. The flood magnitude for the 1-2 year storm also increased by more than 5 times from 1965-2000. (White and Greer, 2004)

Northern California example to be added (Suggestions welcome!)

California NEMO Partners:

California Coastal Commission
California EPA, Office of Environmental Health Hazard Assessment
USC Sea Grant
State Water Resources Control Board
California Association of Resource Conservation Districts
Local Government Commission
El Dorado County RCD
Rivers and Mountains Conservancy
California Integrated Waste Management Board

© The University of Connecticut. Adapted with permission of the University of Connecticut Cooperative Extension System.

For more information, contact the CA NEMO Partnership:

Tracy Duffey
California Coastal Commission
89 South California St., Suite 200
Ventura, CA 93001

Email:
tduffey@coastal.ca.gov
Tel:
(805) 585-1809
Fax:
(805) 641-1732

In a Nutshell

Increased impervious cover associated with urbanization alters the natural cycling of water. Changes in the shape and size of urban streams, followed by decreased water quality, are the most visible effects of increased imperviousness. Alterations in the aquatic environment associated with these hydrological changes greatly compromise the normal functioning of our waterways. Increased frequency and severity of flooding, channel erosion, and destruction of aquatic habitat commonly follow watershed urbanization.

Quick Facts

- ✓ 65% of impervious surfaces are for transportation.
- ✓ Drainage systems consist of everything that water flows over or through.
- ✓ Total Impervious Area is the key index for gauging impacts of urbanization on streams.
- ✓ A watershed is the landmass that carries surface water runoff into a common waterway.
- ✓ Intermittent streams in arid regions of California are more sensitive to total IC than streams in other areas.
- ✓ 75% of the U.S. population lives in urban areas

References

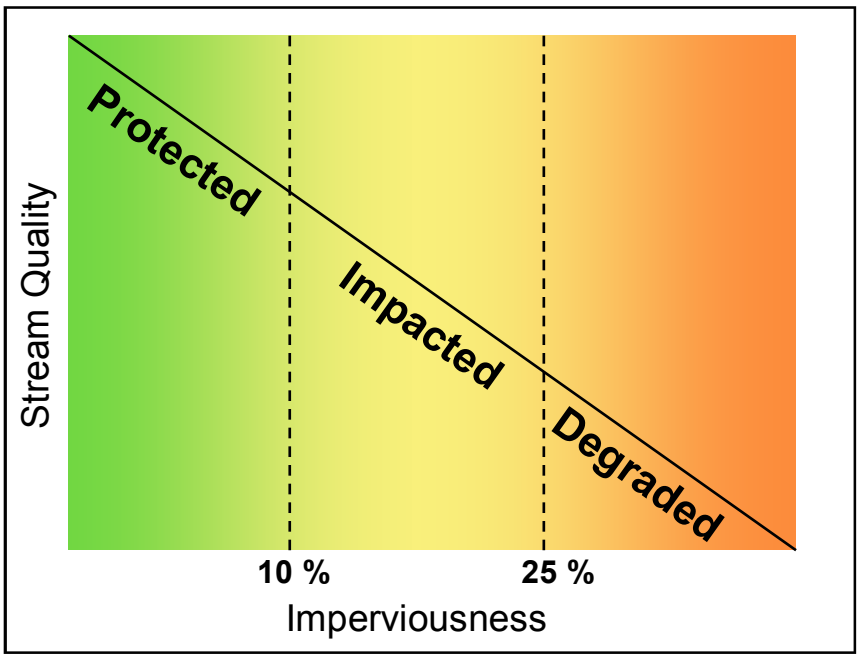
1) Center for Watershed Protection. “Impacts of Impervious Cover on Aquatic Systems”, Ellicott City, MD, 2003.

2) Geosyntec Consultants. “Santa Clara Valley Urban Runoff Pollution Prevention Program Hydromodification Plan Literature Review, Walnut Creek, CA, 2002.

3) White, Michael D., and Keith A. Greer. “The effects of watershed urbanization on the stream hydrology and riparian vegetation of Los Penasquitos Creek, California, 2005.

4) American Society of Civil Engineers. “Effects of Watershed Development and Management on Aquatic Ecosystems”, 1996. New York, NY.

5) Knudson, Tom, and Nancy Vogel. "The Gathering Storm Part II, Bad land-use policies invite a catostrophe." The Sacramento Bee 24 Nov 1997. 21 Jul 2005 <http://www.sacbee.com/static/archive/news/projects/gathering_storm/floodplains.html>


Protected
Impacted
Degraded
Stream Quality
10 %
25 %
Imperviousness