CHAPTER 1

Selecting Stormwater Management Practices for Development Projects

This chapter describes common impacts to prevent as well as the major objectives to apply in order to protect water resources during the development process. Understanding the nature of the impacts prepares site designers to better manage these through alternative site layout and the implementation of practices. Principles utilized during design are provided through stormwater management objectives that also direct designers to the appropriate portions of the manual for applications.

1.1 Adverse Effects of New Development on Water Resources

In order to protect water resource integrity, several impacts must be addressed during development:

- Hydrologic changes of the landscape
- Changes to the drainage network – streams, ditches, swales, waterways
- Increased delivery of warmer, more polluted runoff

Hydrologic Changes

How water is intercepted, stored, used, lost or gained changes substantially after development. Less rainfall is intercepted and utilized by vegetation after development. Less rainfall is infiltrated and percolated into the soils and groundwater following development. And less rainfall is stored in or on top of the ground following storms. All of these hydrologic changes result in more stormwater runoff reaching creeks or rivers faster than before development.

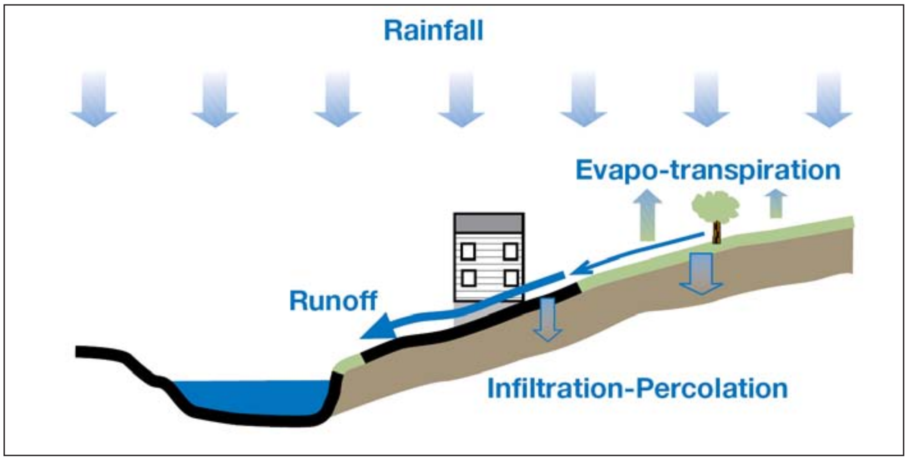
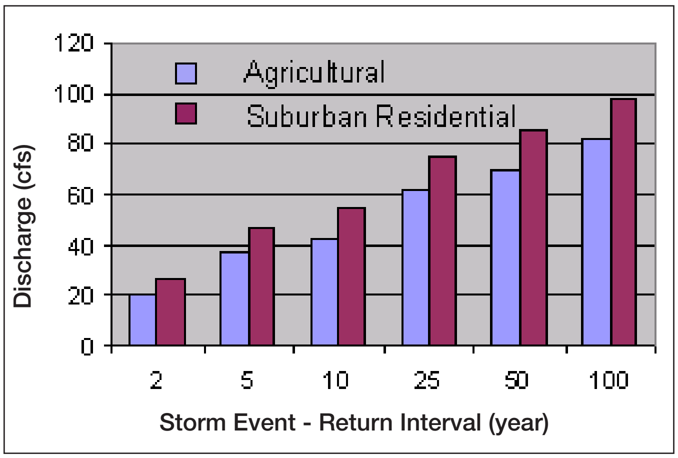


Figure 1.1.1 The hydrologic cycle is altered during urbanization.

The total volume of runoff increases significantly after development as rooftops, roads and hard surfaces replace soil and vegetation. There are other corresponding changes in the hydrology of a developed site. The hardening of a watershed, the compaction of soils, and the direct impacts to streams contribute to them becoming flashier, that is, flows quickly rising and quickly diminishing after each rainfall. Groundwater, normally replenished by percolating rainfall, receives lower levels of recharge in urban areas, affecting both the human and natural communities dependent on groundwater. Wetlands and small streams that require groundwater recharge to sustain them are impacted hydrologically. In its extreme, reduced groundwater recharge, with the subsequent reduction in base flow, may cause former perennially flowing streams to cease flowing during dry periods.

As watersheds urbanize and contribute more runoff, downstream areas experience greater flooding and longer duration flows. It's important to note that even as communities enact flood control strategies, there is still more flow in streams after development that increases flooding and stream erosion.



Storm Event Return Interval (years)	Pre-development Discharge (cfs)	Post-development Discharge (cfs)	Percent Increase
2	21	27	29%
5	37	47	27%
10	43	55	28%
25	61	75	23%
50	70	85	21%
100	82	98	20%

Figure 1.1.2 Stream discharge increases as land use changes from cropped agricultural land to residential using USGS empirical equations for estimating discharge for small urban streams.

To illustrate changes in peak runoff from urbanization, stream discharges were calculated for a typical development site in Eastern Franklin County, Ohio. The peak discharges were estimated for the pre-development condition (agriculture) and the resulting residential development using empirical equations developed by the U.S. Geological Survey (Sherwood, 1986[1]). The table and graph above show the resulting increases in stream discharges. The result was an average 25% increase for the 2, 5, 10, 25, 50 and 100-year return intervals in the estimated peak stream discharges. In water cycle terms, as land urbanizes, significantly less rainfall infiltrates and transpires from vegetation, therefore substantially increasing runoff to streams.

Storm water runoff to this ravine has caused over 2 feet of vertical stream erosion (incision).

Stream Instability and Consequences

As faster and higher stream flows occur on a regular basis, stream channels typically respond by adjusting their shape and size through erosion. Unfortunately, the typical pattern in urban areas is that a healthy stream with a naturally stable form (where bank erosion is balanced by floodplain deposition) becomes physically degraded. The stream cuts downward, losing access to its floodplain and the many functions provided by the floodplain and stream corridor. These deeply entrenched urban streams provide less storage and treatment of stormwater runoff along their corridor than healthy channels. These streams are plagued with bank erosion, contribute more sediment to downstream areas and rarely maintain high quality habitat features such as clean gravel substrates, deep pools and stable riffles. While rehabilitation of degraded streams is possible, the high cost and difficulties associated with working near developed properties makes it critical to prevent these problems in the first place. It makes sound economic and ecological sense.

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[1] Sherwood, J.M. 1986. *Estimating Peak Discharge, Flood Volumes, and Hydrograph Shapes of Small Ungaged Urban Streams in Ohio*. USGS Water Resources Investigation Report 86-4197, 52 pp.

Stream instability associated with stormwater increases often brings hard and harsh solutions.

Thermal, Biological and Chemical Pollution

Increased development results in more pollutants and in more runoff, with the result that the pollutant loading from each storm event is markedly higher after development. Development also reduces the watershed's natural treatment (assimilation) as runoff speeds toward the stormwater system and streams without opportunity to soak into soils. The chemical quality of urban runoff is diminished as concentrations of suspended fine sediments, nutrients, oxygen-demanding materials, bacteria, heavy metals and hydrocarbons from oil and gas, pesticides, chlorides from road salt increase. Urban runoff has been shown to have pollutant concentrations similar to sanitary wastewater. Unfortunately stormwater systems traditionally have been designed so that these constituents – once in runoff – have little opportunity to be removed before reaching a lake, creek or river.

Numerous pollutants of concern are concentrated in urban runoff and urban stream systems. Hydrocarbons, associated with petroleum products, concentrate in high traffic areas and concentrate in sediments of urban streams. A California study also found sediments in urban streams had 3 to 10 times more heavy metals than non-urban stream. The United States Geological Survey has sampled urban runoff, and commonly found herbicides, high phosphorus levels, and fecal coliform in concentrations that exceed recommendations for water contact.

The temperature of runoff from urban land uses is much higher than normal stream flow and increases the threat to stream life. Fewer trees along urban creeks often compound the problem by allowing sunlight to warm the water surface. High temperatures stress aquatic organisms by pushing them towards or beyond their temperature tolerances in warmer seasons and by lowering the oxygen-holding capacity in the water. Often the low amount of dissolved oxygen in urban stormwater is indicated by a sewer-like smell.

Summary of Urban Water Resource Problems Related to Development:

- Increased pollutant availability
- Increased runoff
- Increased peak flows and stream “flashiness”
- Stream Instability
- Decreased stream function in incised and modified channels
- Decreased storage and treatment of stormwater along stream channels
- Increased stream temperature
- Decreased groundwater recharge
- Decreased baseflow for streams and wetlands
- Less natural pollutant assimilation in soils
- Diminished aquatic life

Urbanization and Stream Decline

Studies indicate that even at low levels of urbanization (5-10% imperviousness) stream ecosystems begin to rapidly decline (Schueler, 1994[1]). These urban streams lose much of their biological diversity, leaving only populations of pollution tolerant species. A study[1] by the Ohio Environmental Protection Agency of 110 urban sites found poor or very poor scores at the majority of the urban impacted sites (85%). More than 40% of suburban sites were impaired with many reflecting the negative impacts of new developments for housing and commercial uses. As this study stated, "The results demonstrate the degree of degradation which exists in most small urban Ohio watersheds and the difficulties involved in dealing with these multiple and diffuse sources of stress."

[1] Schueler, T. 1994. The Importance of Imperviousness. *Watershed Protection Techniques.* 1(3): 100-111.

[1]Yoder, C.O. and E.T. Rankin. 1996. Assessing the condition and status of aquatic life designated uses in urban and suburban watersheds, pp. 201-227. in Roesner, L.A. (ed.). Effects of Watershed Development and Management on Aquatic Ecosystems, American Society of Civil Engineers, New York, NY.

1.2 Stormwater Management Objectives for Development

This section presents stormwater objectives a site developer must address in planning and designing a development project which protects water resource integrity, along with the specific management practices available for addressing these objectives, and the appropriate chapter in this manual where guidance about these practices may be found.

1. Preserve the natural drainage system and important water resources

The natural drainage system that exists prior to development provides many benefits ranging from stormwater management and drainage services, to natural pollutant removal and wildlife habitat. For this reason, designers must preserve as much of the existing stream system as possible, by preserving streams, their corridors (streamways) and wetlands and by minimizing the extent that storm drains and constructed ditches replace natural drainage ways. Even open swales and ephemeral drainage without well-defined channels provide valuable stormwater benefits and should be preserved where possible.

Developments that build too close to watercourses may cause significant problems after the property is occupied since:

- structures on active floodplain areas may be damaged by flooding
- loss of natural floodplains increases flooding and pollutant loads, and decreases natural stream stability elsewhere along streams
- property or infrastructure may be damaged by natural stream migration or movement (meandering), or the elevated groundwater associated with saturated floodplains or wetlands
- stream integrity may be degraded due to the loss of the natural riparian corridor

For these reasons, this manual strongly encourages site designers to begin site layout by defining the existing drainage system, an adequate stream corridor, and floodplains based on the projected built out conditions in the watershed. The following management practices in Chapter 2 and additional resources will help achieve this objective:

• Wetland Setbacks	Chapter 2, Page 15
• Stream Setbacks	Chapter 2, Page 21
• Stream and wetland permitting	Appendix 2

2. Minimize imperviousness of the proposed development

Minimizing imperviousness must be a major objective during site layout. Numerous studies show that increases in pollutant loads, runoff volumes, and peak discharge rates are directly related to increases in the impervious areas within a watershed or project area. The greatest opportunity to reduce imperviousness lays in the sizing and layout of streets and parking areas. Parking standards traditionally have promoted having excess parking even during peak use. Some communities have begun to modify parking requirements to reflect stormwater concerns. Where building regulations and zoning allow, options such as reduced parking ratios or shared parking, clustered development reduce total site imperviousness and often reduce development costs.

Streets should be designed for the minimum pavement area to support the uses and the traffic based on the expected volume of traffic and the access needed. Alternative residential street layouts that maximize the number of homes per length of street also help reduce overall imperviousness. In commercial development, separating frequently utilized parking areas from rarely used areas provides an opportunity to use alternative parking materials such as modular pavers that reduce runoff and allow some infiltration in low use areas. Even without changing ordinances and development regulations, site designers have potential to reduce excess imperviousness by not exceeding minimum standards and utilizing shared parking between compatible uses, and variances may be an option. Of course, the area not used for parking must be replaced with open space or landscaping, not with other impervious surfaces.

Where hard surfaces cannot be reduced for development goals to be achieved, it may be possible to "disconnect" impervious surfaces from the drainage system and provide opportunities for runoff from small storms to percolate into the soil.

The following management practices in Chapter 2 may be used to achieve this objective:

- Low Impact Development — Chapter 2, Page 3
- Impervious Area Reductions — Chapter 2, Page 5
- Conservation Subdivision Design Principles — Chapter 2, Page 11

3. Improve degraded streams

In many cases, a watercourse through or adjacent to a development project has been degraded by past land uses and/or upstream development. Occasionally a developer may be relocating portions of a degraded watercourse during development. Developers may also be required to restore watercourses to mitigate for on-site impacts. In other cases, eroding channels may need special measures to prevent further degradation that can be more easily addressed during development or can prevent substantial future property loss.

In any of these cases, guidance in Chapter 3 can be used to address issues of degraded stream resources. Ultimately, by promoting or maintaining the naturally sustainable functions of these streams, many valuable stormwater management and water quality services will be provided via functional streams in addition to those provided through the still critical individual best management practices. Protection and restoration of floodplain and stream resources provide benefits of sediment reduction, nutrient removal and higher quality stream habitats. Restoration and rehabilitation of streams is best accomplished before or during development, since there are fewer impediments regarding stream access, and movement of materials and equipment. Costs increase and managing restoration/rehabilitation projects become more difficult as the area around the stream becomes more developed. Other issues such as the use of soil from previously filled floodplains can be more easily solved if coordinated with the site development plans.

The practices and reference materials in Chapter 3 and Appendix 7 may be used to address unstable and degraded streams.

4. Plan additions to the site drainage system that are stable and sustainable

Often the changes in runoff that occur during development will subject some areas, such as existing swales or watercourses to increased erosion. Areas of particular concern on developed sites include outlets from storm sewers and detention facilities, open drainage ways, areas receiving concentrated flow, and slopes.

Chapter 4 of this manual provides guidance on permanent runoff controls that typically must be installed during development to convey runoff and prevent accelerated erosion.

5. Manage post-construction runoff

Nearly every development project will require measures to control the impacts of increased runoff from the project. Those impacts include:

- Higher peak discharges
- Increased runoff volume
- Accelerated flow velocity
- Elevated pollutant loading

An effective system of stormwater runoff controls will address the increased energy and frequency of peak flows, as well as the increased pollutant load in the runoff. These controls must be in place throughout the watershed to address the cumulative impacts of urban land uses on stream stability, downstream flooding and water quality.

Stormwater management practices typically perform multiple functions including flood control, pollutant removal, and reducing downstream erosion potential. Stormwater practices can be integrated into the landscaping, drainage network, and other open spaces of development projects. Properly designed they can become amenities rather than impediments to development projects.

Chapter 2 and Appendix 1 provide guidance on the design, construction, and maintenance of the most common stormwater management practices that incorporate water quality and stream protection applications. The control practices described have: a proven performance track record, wide applicability within Ohio, and extensive resources available about their design, construction, and maintenance. Alternative measures are evolving but should be considered only if extensive data and justification can be presented to support their proper design and long-term performance.

The following management practices in Chapter 2 may be used to achieve this objective:

- Water Quality Ponds — Page 2-27
- Infiltration Trench — Page 2-41
- Sand Filter — Page 2-49
- Grass Filter — Page 2-63
- Bioretention Area — Page 2-69

6. Control erosion and sediment impacts during construction

Construction and associated earthmoving activities cause high sediment loads in construction site runoff. Planning for these controls begins during site layout, with overall sediment and erosion control strategies developed during the final phases of project design. While implementation of construction-phase controls is left to the contractor, they must be guided by the strategies specified by the site designer in construction plans.

Chapters 5 *(Temporary Runoff Controls)*, 6 *(Sediment Controls)*, 7 *(Stabilization Controls)* and 8 *(Additional Construction Site Pollution Prevention and Small Construction Site Controls)* of this manual describe the appropriate controls for construction phase impacts. Chapter 5 shows practices that direct muddy runoff toward sediment controls, manage runoff in order to prevent erosion and allow stable crossing of streams. Sediment control practices from Chapter 6 are utilized to remove sediments from runoff before it leaves the construction site. Effectively establishing vegetative cover on disturbed areas is the focus of Chapter 7, Stabilization Controls. This chapter also describes dust control, limiting soil disturbance and methods of temporary stabilization. Chapter 8 describes how small building lots can provide erosion and sediment control and handling of additional sources of pollutants, such as fuels and construction materials.

7. Control high risk pollution sources

Chapter 8 *(Additional Construction Site Pollution Prevention)* gives descriptions of non-sediment pollution concerns existing on construction sites and other state requirements for these as well as management recommendations. Some land uses such as industrial areas may have a high risk of releasing pollutants and may not have appropriate practices described here. Most of the stormwater management measures described in chapter 2 of this manual are not appropriate for treating pollutants from: material and waste storage and handling; vehicle fueling and service; equipment cleaning areas or other areas that contain pollutant concentrations significantly higher than typical urban runoff. Runoff from these activities should be segregated from other site runoff and directed to more advanced treatment options such as oil-water separators, containment systems, or sanitary sewers. Alternatively, areas where these activities occur could be covered and/or moved indoors.

U.S. EPA and Ohio EPA offer additional information regarding safe material storage, containment and pollution prevention practices in their NPDES permit program materials regarding pollution prevention and good housekeeping for municipal operations.

8. Assure long-term access to and maintenance of stormwater system

Regular inspection and maintenance of stormwater controls are necessary if these controls are to consistently perform up to expectations. Developers and municipalities must address these issues during project design. Facilities that are inaccessible and/or lack features to facilitate maintenance will become a nuisance. A reliable party with adequate funding to perform maintenance is essential – many communities that have overly relied upon property owners, homeowners associations, and similar parties to perform maintenance have ultimately had to assume these responsibilities, often at a much higher cost than if the facility design and institutional arrangement had been established at project inception.

Suggested maintenance practices are included with each control measure in this manual.