3 Watershed Basics 101

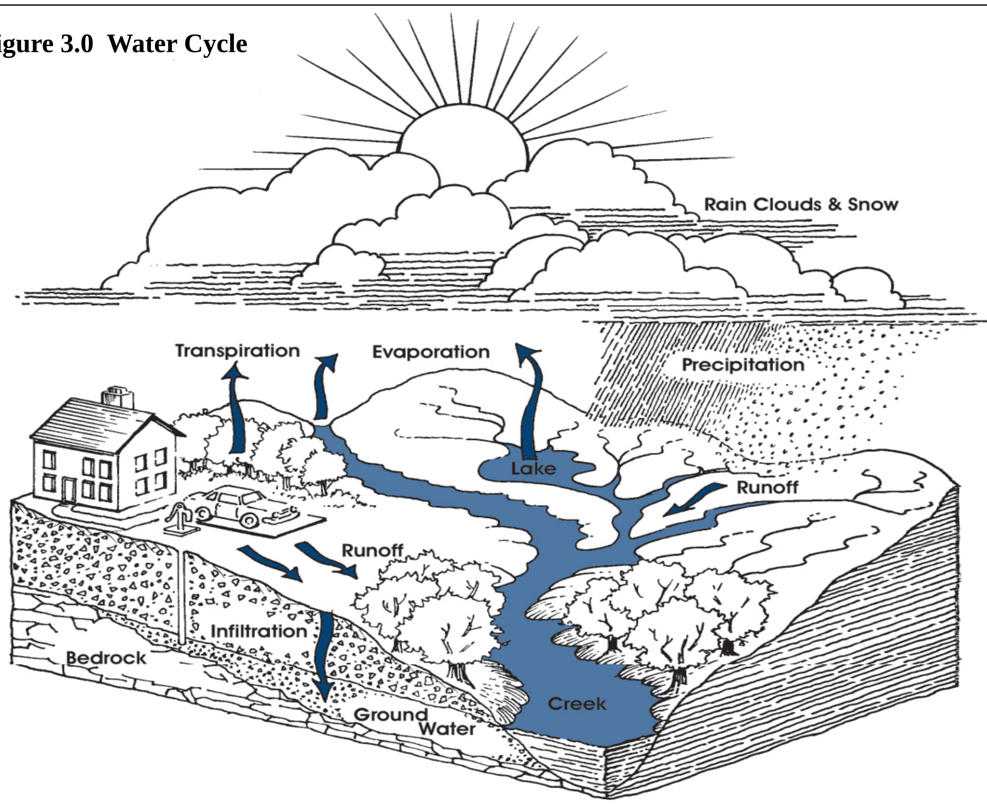
To enhance watershed understanding and to keep readers and RCP partners on the same page about the terms, concepts, and principles used in this plan, *Watershed Basics 101* explains the water cycle, the 'sheds, and how other aspects of Paxton Creek work. A separate Appendix provides extensive details. A glossary of Terms, Abbreviations, and Acronyms located at the end of this RCP document can also be of assistance.

"Fellow watershed planners, we have just received some decision making materials from the folks in a neighboring watershed!"

Can You Park Your Water Cycle in a 'Shed?

Paxton Creek's problems and solutions start with the *water cycle*. Natural water flows are a cyclic process involving various forms of precipitation (mainly rain and snow) that fall to the ground, soak into soils, and fill crevices and cracks in rocks. (Figure 3.0) While local water uses and land changes are often too small to alter the overall water cycle, such activities can markedly affect local water patterns (trees cut, and soils covered or compacted can decrease stormwater infiltration and increase runoff).

Figure 3.0 Water Cycle

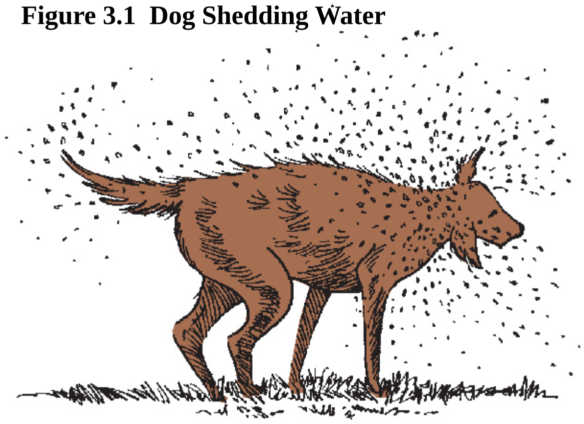


"Limiting stormwater responsibilities to development sites doesn't give a d#mx about people downstream."

Watershed Basics 101

Water that doesn't soak into the ground runs off the landscape from areas called watersheds. Analogous to water falling off a dog, watersheds are places ('sheds) where the water runs off lands. (Figure 3.1) The boundaries of 'sheds are mainly determined by landscape topography. Water runs from high points (elevations) in all directions downslope until the next 'sheds. Watersheds include everything in drainage areas – all vegetation, roads, buildings, streams, lands, and groundwater. Watersheds come in all sizes, and different terms are used to describe them. (Figure 3.2) They typically range from catchments of a few acres or smaller, to increasingly larger areas: subwatersheds, watersheds, and basins. While integrated water resource planning may occur at the watershed level, the ideal size for implementation and management is often the subwatershed. The subwatershed planning unit is small enough to get things done, and still contribute to the big picture. It is small enough to determine the causes of creek degradation, allows recognition of local development impacts, and reduces the need to deal with multiple political jurisdictions. Tasks like mapping, monitoring, and other assessments can be done in a shorter time, without undue burdens on work in the larger watershed. A subwatershed plan can generally be carried out within a year, still allowing time for the essential tasks of: goal development, data collection and evaluation, project design, agency coordination, and stakeholder involvement. It will be necessary to plan individual rehabilitation projects at the catchment level.

Figure 3.1 Dog Shedding Water



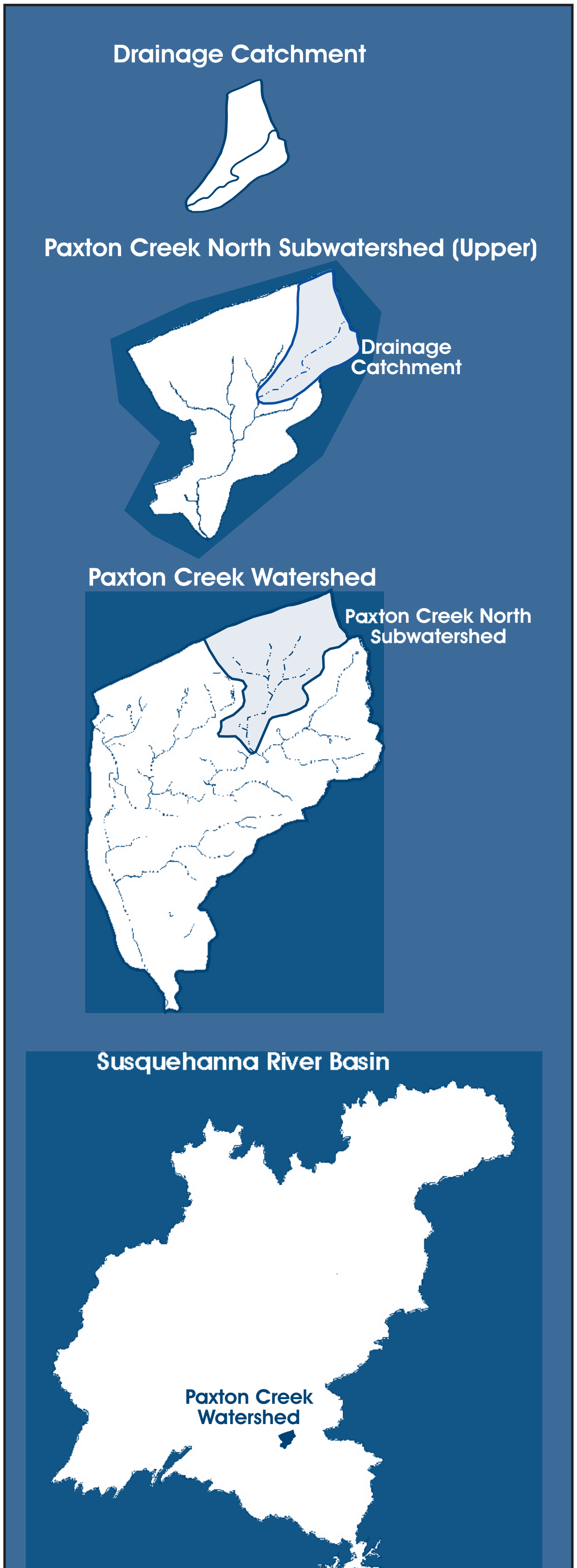


Figure 3.2 Watersheds

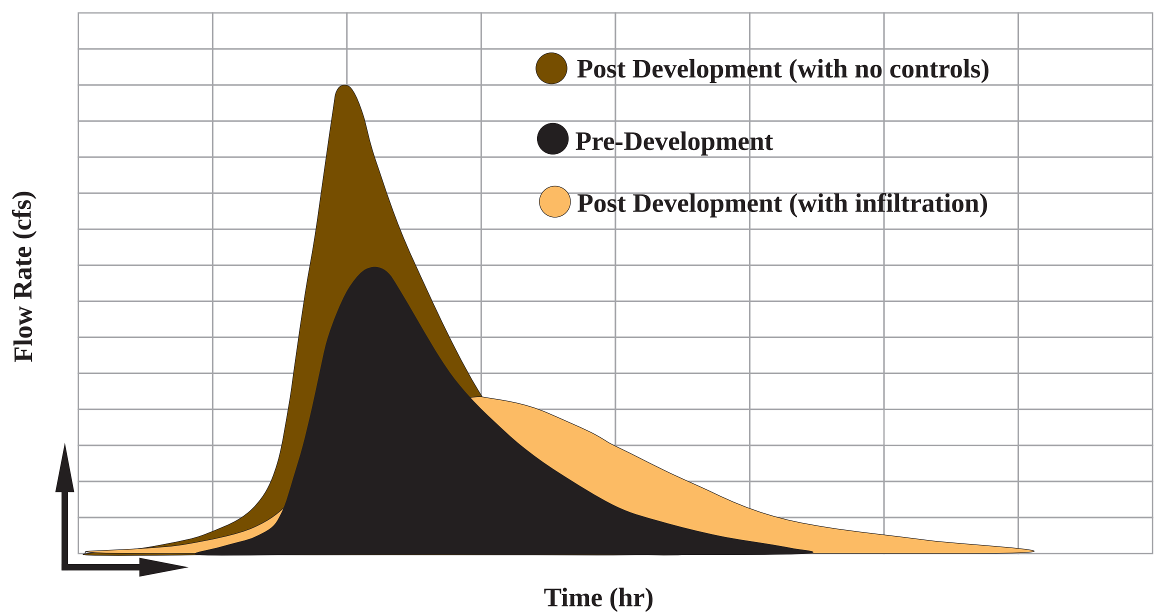
Where is the Rapid Runoff Rapid?

A water diagram called a *hydrograph* represents the amount and pattern of water flow during a given time period. A hydrograph generally has a shape similar to an abstract profile of a mountain peak (Figure 3.3) This diagram also shows the runoff pattern where the land cover is steeper, harder, or smoother, allowing stormwater to run off faster and have higher maximum flows, especially from surfaces that are impervious (blocked) to water flows.

Stormwater flowing off impervious surfaces (roofs, roads, parking lots, packed dirt, and even tight grasses) rises higher and falls more quickly. The higher peaks reflect increasing potential for flooding, worsening water quality (higher sediment and phosphorus loads), increasing creek warming (detrimental to fish), and decreasing biodiversity (kinds of aquatic insects, fish, and other wildlife).

The lowest, broad peak below (orange color) illustrates the effect of stormwater soaking into the ground where the precipitation falls or close by. In housing developments this occurs where runoff is directed into yards (rain gardens, conservation landscaping, swales) rather than conveyed by gutters, drains, and pipes directly to streams.

Figure 3.3 Stormwater Runoff Hydrographs



Note: Modified from DEP, 2005

Watershed Basics 101

The aim of effective stormwater control practices is to shorten the hydrograph peak and broaden its shape. Conventional ways of managing stormwater runoff in central PA aim at reducing the peaks on hydrographs at development sites, but developers focus on sites, not downstream impacts. Upstream waters released too quickly from multiple places can, and do combine downstream to cause flooding, severe erosion, sedimentation, and other problems. This pattern has been the bane of Paxton Creek watershed, especially during the initial land transformation period and the last half century of accelerated urbanization.

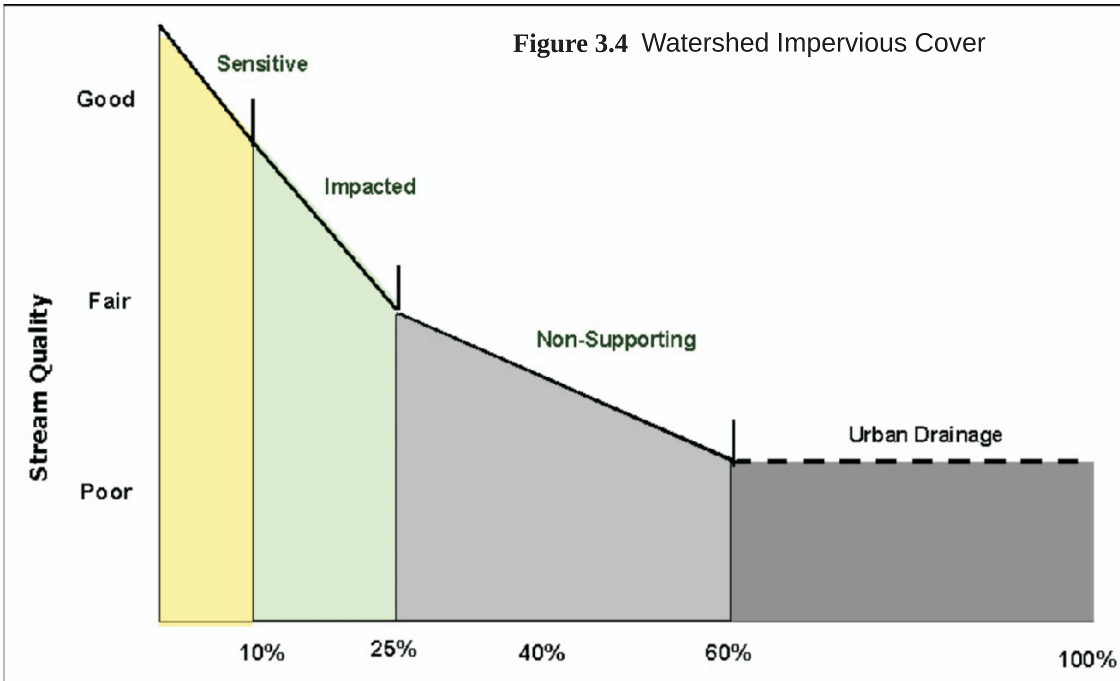
Impervious Cover Model

Following a review of hundreds of studies, the Center for Watershed Protection (2000) proposed a scheme for classifying urban streams based on extent of imperviousness. This approach assigns streams to three management categories: under 10 percent imperviousness, sensitive; 11-25 percent imperviousness, impacted; 26 percent and above, non-supporting (of wildlife). Different watershed improvement approaches are recommended according to this breakdown. (Figure 3.4)

This scheme is used in the Paxton Creek RCP. Paxton Creek has extensive impervious surface (30% overall, and a range of 9 to 56% in the subwatersheds). (Table 4.1)

This impervious cover model is a general screening tool, not the basis for decisions on specific sites. Paxton Creek has some places with stream quality better than the model suggests (Upper Paxton Creek North headwaters), just as the poor stream habitat near the Harrisburg (East) Mall does not represent Spring Creek's ability to support a thriving trout population downstream

Figure 3.4 Watershed Impervious Cover



Source: CWP, 2004

Are Surface Waters Well Grounded?

The watershed has water in the ground, on the surface, and in the air. Ground water is precipitation that has percolated into rock fractures underground, and/or into soils, saturating particles of sand, gravel, silt and clay. The underground rock layers containing ground water are called *aquifers*. (Figure 3.0)

Ground water that seeps into streams makes up their *base flows*, and sustains animal critters during droughts. In Paxton Creek, the base flows are reduced where stormwater runs off, rather than infiltrates into the ground.

The quality of ground water is generally better than surface water, due to cleansing of polluted water as it seeps through the soils. Ground and surface waters are interconnected, making ground water vulnerable to contamination by surface water, and vice versa.

Surface waters, mainly in creek tributaries, lakes, and ponds are determined by geology, drainage area, topography, land cover, land uses, and climate (storm intensity and duration). Most surface waters in the watershed are branches of the creek formed from precipitation falling into low landscape depressions, and running down slopes to combine with other runoff, forming larger and larger flows. The initial small flows forming distinct streams are often termed *first order* tributaries. These can be the creek headwaters.

Erosion and Bank Slump

Throughout much of Paxton Creek watershed, surface waters have deeply incised the creek channels. Erosion has occurred to an extent that only runoff from major storms will cause the creek to rise above its banks and empty onto the floodplains. Excessive runoff has cut the creek, first to bedrock and then sideways, causing damage to the creek's channels and banks. Impacts include loss of aquatic habitat for animals, toppled trees, lowered water quality, and under recharged aquifers with associated degradation. The creek cannot adapt quickly enough to the accelerated stormwater runoff, making Paxton Creek a stream out of balance with its watershed.

How About Water Quality?

When people talk about quality, they are concerned about how good or bad something is. When the subject is water, the concern is what is in the water (kinds and amounts), sources, and the water conditions (waterway erosion, habitat suitability for wildlife). The things in the water that restrict, or limit water uses are called *pollutants*. Some pollution in natural waters is common. All things in water are not bad, but most can be problems if they are excessive or too sparse for desired conditions.

Collecting Sediment Sample

Various categories of factors used in assessing water quality are called *parameters*. They generally are of three types: physical, chemical and biological. The physical parameters are factors such as water temperature, flow level, and current speed. A wide variety of chemical parameters include pH (amount of acidity), dissolved oxygen, nutrients, and metals. The biological parameters are plants and animals living in waters. Creatures play a special role in water quality determinations. While physical and chemical measurements can show harmful conditions or substances when they are present, populations of organisms can function as "floral and faunal memories" for sites. Their abundance and diversity reflect past history, and may indicate a poison, major stress, or even a beneficial factor affecting or passing through the aquatic community. In Paxton Creek all three types of parameters are used in monitoring. (Table 3.0)

Table 3.0 Paxton Creek Pollutants

Pollutant	Source
Fecal Coliform Bacteria	Sewers and other animal waste sources (e.g., pets, wildlife, livestock, truckers)
Debris	Landscape and yard waste, local floods
Heat	Asphalt and concrete surfaces (e.g., parking areas, roads), industrial discharges
Metals	Transport vehicles, industries, degradation (e.g., rusting)
Nutrients	Agriculture, lawns, gardens, vehicle emissions, golf courses
Pesticides	Agriculture, lawns, gardens, homes, businesses, golf courses
Petroleum Hydrocarbons	Vehicle emissions, fuel and lubricant spills, lot and road runoff
Salt (NaCl)	Roads, sidewalks, landscape materials
Sediment	Erosion of soils

Another way to look at pollutants is their source. Two broad groups are *point source* and *nonpoint source pollutants*. Those from point sources typically emanate from distinct places such as animal feedlots and pipes from toilets, industrial plants, and municipal treatment facilities. These point sources were the main regulatory focus for over 30 years, and programs were established for their systematic monitoring.

Important also to the watershed is pollution from nonpoint sources, which by definition are places dispersed across the landscape such as farm fields, parking lots, yards, motorized vehicles -- almost everywhere. These nonpoint source pollutants typically are conveyed as contaminants in stormwater runoff.

What Are Some Ways To Improve the Watershed?

The current term for optimal approaches dealing with watershed resources is *Best Management Practices (BMPs)*. BMPs are methods, measures, or practices to avoid, prevent, reduce, or mitigate undesirable effects or outcomes.

BMPs are of two types: structural and nonstructural. The structural ones use physical entities (soils, vegetation, machines) to accomplish objectives. The nonstructural alternatives include approaches such as schedules, operation and maintenance procedures, and changed practices for achieving the desired results. Well managed BMP programs often integrate the two groups.

Figure 3.5 Rain Garden

Water Resource BMPs

Water resource BMPs have various functions: reduce runoff, infiltrate water, recharge aquifers, prevent pollution, and improve water quality, while achieving other benefits such as yard and garden beautification and increased wildlife habitat. Especially useful in Paxton Creek are retrofits of existing facilities for better stormwater management, and pollution removal. Combinations of BMPs are necessary to achieve all the benefits. The most effective water resource BMPs generally simulate crucial elements of natural processes. Typical water resource BMPs are landscape depressions such as *rain gardens* (Figure 3.5) , *bioretention areas*, and *swales* where vegetation captures and treats stormwater runoff before it enters receiving waters; *pollution prevention/source control practices* that reduce or prevent nonpoint source pollution from yards and dumpsters; *forested* creek corridors (shrub and tree buffers) that filter runoff and reduce pollutants entering the creek, stabilize stream banks, regulate creek temperatures, and provide habitat for aquatic and terrestrial wildlife. (Figure 3.6)

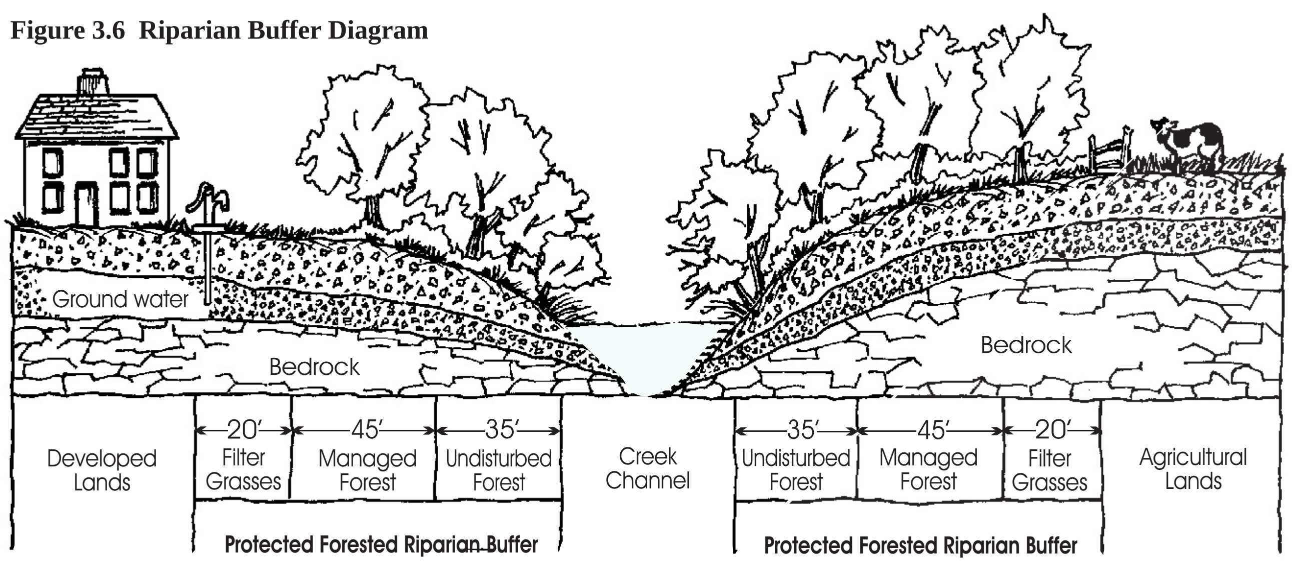
Land Management BMPs

Land–the way it is used, who owns it, who manages it, and how it is regulated are keys to watershed degradation and rehabilitation. Much of Paxton Creek's decline is due to past and recent land disturbances. (Table 2.1)

Figure 3.7 Roundtable Planning

Alternative ways for diminishing land use problems, while providing many benefits, are conservation or better site design (BSD), and low impact development (LID) techniques. The dozens of land related BMPs include: *growth management strategies* (utilities, roads restricted to areas of desired growth); *impervious surface retrofits* (converting impervious cover into areas where stormwater soaks into soils thereby reducing runoff and enhancing water quality – backed by n*ew ordinances* used by creek municipalities. Many approaches are included in a booklet of 23 non-binding development principles formed and adopted by representatives of home builders, community organizations, and local government staff during recent Paxton Creek Roundtable discussions. (Table 3.1; Figure 3.7)

Figure 3.6 Riparian Buffer Diagram



Adapted from Water Resources Authority, 2002

Table 3.1 Partial Paxton Creek Roundtable Principles

Streets and Parking Areas

☑Allow narrow streets, and reduce their total length.
☑Eliminate road curbs, gutters, drains & use vegetated swales for stormwater.
☑In cul-de-sacs use depressed landscape islands with infiltration & bioretention practices to reduce impervious cover and to treat stormwater runoff.

Building Lots

☑Offer density bonuses and other incentives for connecting open space developments.
☑Reduce minimum front and side yard setbacks, and lot frontage.
☑Direct rooftop, patio, or other runoff into pervious areas such as yards, rain barrels, rain gardens, open channels and other techniques to infiltrate runoff.

Natural Area Protection

☑Adopt ordinances requiring riparian buffers of suitable width with native vegetation.
☑Minimize clearing and grading (grubbing) native vegetation; conserve trees; and protect open space.
☑Consider incentives to encourage the preservation of large, contiguous land parcels such as allowing greenways, density compensation, and property tax reductions.
☑Establish a pre-planning process for development sites to address the incorporation of better site design principles up front in the planning stage (natural features protection, site inspection) …etc.

Adapted from *Alliance for the Chesapeake Bay,* 2003

Beautiful, Bountiful Buffers

Buffers play a special role in watershed management. These vegetated strips between lands and waters are possibly the most important of all the BMPs. In addition to the benefits already described, buffers can prevent many creek problems from ever starting! If they are so good, why don't we see more of them? Why are they often fragmented and of poor quality? It is a matter of priorities and ignorance: some people want to develop every inch of their lands; others don't want wildlife around; others like clean, immaculate yards (effective buffers often look dense, and messy), and so on. Effective buffers vary greatly in width (20 to 300 feet) and consist of one of more bands (3 zones depicted in Figure 3.6), depending on what is wanted (from water temperature modulation to wildlife habitat), and local conditions (soils, slope, amount of runoff, types of pollutants). What is best for Paxton Creek watershed, an urban area where buffers may also contain trails? A width of at least 75 feet is recommended.

Attachment RCP-2 contains the complete array of development principles adopted by the Paxton Creek Roundtable. Both water and land management approaches have been slow to come to central Pennsylvania for various reasons and excuses: liability concerns; reluctance to try new things; bias towards concrete and steel rather than solutions featuring vegetation; ignorance of technical details; lack of laws and ordinances with incentives encouraging BSD, LID; and other approaches.

Planting Creek Buffer

Many more BMP alternatives with details and expansive considerations concerning land, water, and other topics (creek-based recreation, economic development education) are associated with strategies and tactics in the plan Attachment RCP-3.