Article 27

Chapter 2 from The Rapid Watershed Planning Handbook

The Tools of Watershed Protection

In this article, we outline a watershed protection approach that applies eight tools to protect or restore aquatic resources in a subwatershed. These tools are as follows:

Tool 1. Land Use Planning

Tool 2. Land Conservation

Tool 3. Aquatic Buffers

Tool 4. Better Site Design

Tool 5. Erosion and Sediment Control

Tool 6. Stormwater Best Management Practices

Tool 7. Non-Stormwater Discharges

Tool 8. Watershed Stewardship Programs

The practice of watershed protection is about making choices about what tools to apply, and in what combination. The eight watershed protection tools roughly correspond to the stages of the development cycle from initial land use planning, site design, and construction through home ownership (see Figure 1). As a result, a watershed manager will generally need to apply some form of all eight tools in every watershed to provide comprehensive watershed protection. The tools, however, are applied in different ways depending what category of subwatershed is being protected.

The remainder of this article describes the nature and purpose of the eight watershed protection tools, outlines some specific techniques for applying the tools, and highlights some key choices a watershed manager should consider when applying or adapting the tools within a given subwatershed. Each of these tools is an essential element of a comprehensive watershed protection approach and their goal is to provide local communities with a realistic approach for maintaining a quality environment for future generations.

Tool #1: Land Use Planning

Since impervious cover has such a strong influence on subwatershed quality, a watershed manager must critically analyze the degree and location of future development (and impervious cover) that is expected to happen in a watershed. Consequently, land use planning ranks as perhaps the single most important watershed protection tool. When preparing a watershed plan, a watershed manager needs to do the following:

- Predict what will happen to water resources in the face of future land use change.
- Obtain consensus on the most important water resource goals for the watershed.
- Develop a future land use pattern for the subwatersheds within the watershed that can meet those goals.
- Select the most acceptable and effective land use planning technique to reduce or shift future impervious cover.
- Select the most appropriate combination of other watershed protection tools to apply to individual subwatersheds.
- Devise an ongoing management structure to adopt and implement the watershed plan.

Land Use Planning Techniques

Watershed planning is best conducted at the subwatershed scale, where it is recognized that stream quality is related to land use and consequently impervious cover. One of the goals of watershed planning is to shift development toward subwatersheds that can support a particular type of land use and/ or density. The basic goal of the watershed plan is to apply land use planning techniques to redirect development, preserve sensitive areas, and maintain or reduce the impervious cover within a given subwatershed.

A wide variety of techniques can be used to manage land use and impervious cover in subwatersheds. Some of these techniques include the following:

- Watershed based zoning
- Overlay zoning
- Urban growth boundaries
- Large lot zoning

Local officials face hard choices when deciding which land use planning techniques are the most appropriate to modify current zoning. These techniques have been employed in a wide variety of watershed applications by many local governments across the country.

Watershed-based Zoning: This specialized technique is the foundation of a land use planning process using subwatershed boundaries as the basis for future land use decisions. Watershed based zoning involves defining existing watershed conditions, measuring current and potential future impervious cover, classifying

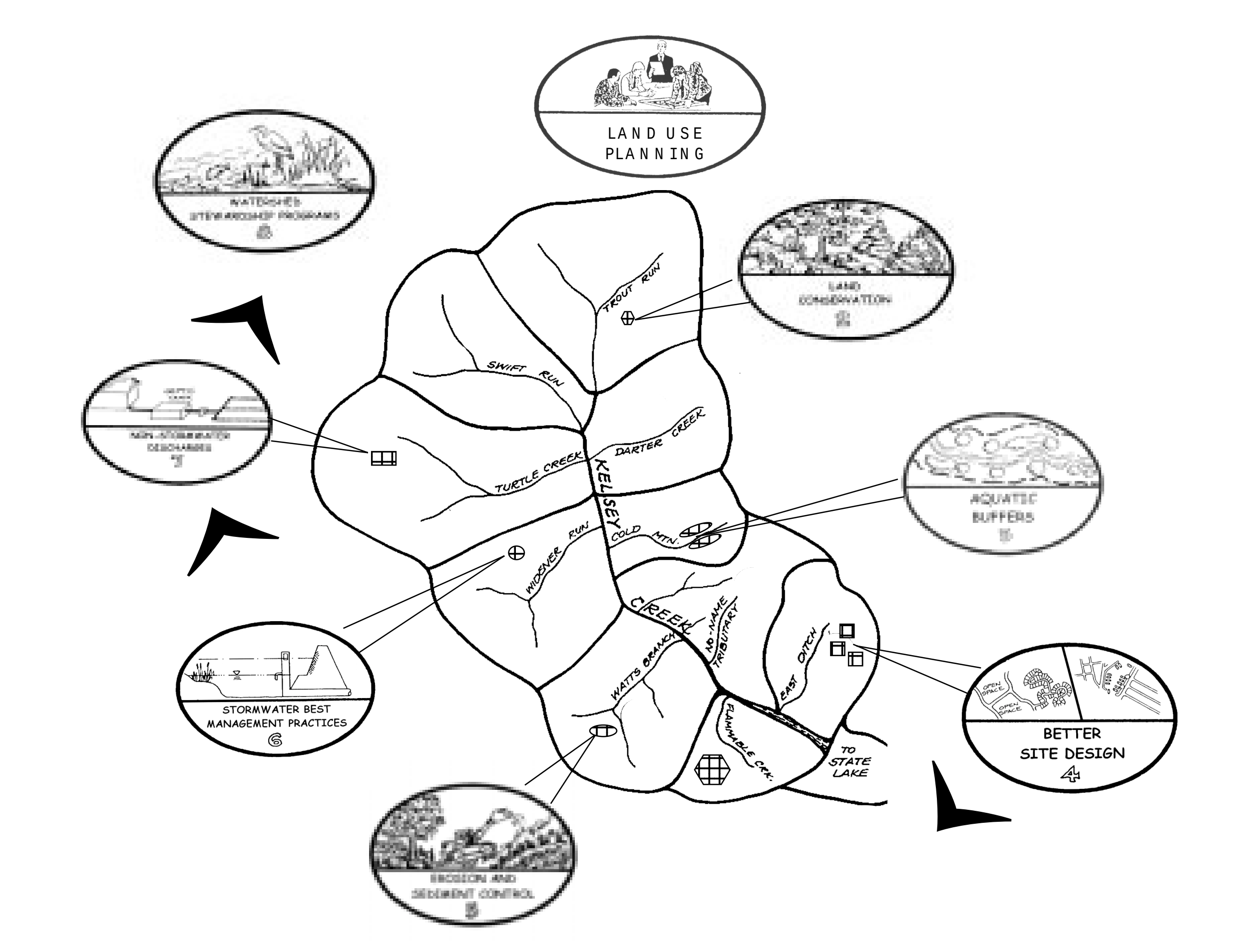

Figure 1: The Eight Tools of Watershed Protection

subwatersheds based on the amount of future imperviousness, and most importantly modifying master plans and zoning to shift the location and density of future development to the appropriate subwatershed management categories. An example of subwatershed management categories within a watershed is shown in Figure 2. Watershed based zoning can employ a mixture of land use and zoning options to achieve desired results. A watershed based zoning approach should include the following nine steps:

1. Conduct a comprehensive stream inventory.
2. Measure current levels of impervious cover.
3. Verify impervious cover/stream quality relationships.
4. Project future levels of impervious cover.
5. Classify subwatersheds based on stream management "templates" and current impervious cover.
6. Modify master plans/ zoning to correspond to subwatershed impervious cover targets and other management strategies identified in Subwatershed Management Templates.
7. Incorporate management priorities from larger watershed management units such as river basins or larger watersheds.
8. Adopt specific watershed protection strategies for each subwatershed.
9. Conduct long term monitoring over a prescribed cycle to assess watershed status.

Overlay Zoning: This land use management technique consists of superimposing additional regulatory standards, specifying permitted uses that are otherwise restricted, or applying specific development criteria onto existing zoning provisions. Overlay zones are mapped districts that place special restrictions or specific development criteria without changing the base zoning. The advantage is that specific criteria can be applied to isolated areas without a threat of being considered spot zoning. Overlay districts are not necessarily restricted by the limits of the underlying base zoning. An overlay zone may take up only a part of an underlying zone or may even encompass several underlying zones. Often the utilization of an overlay zone is optional. A developer can choose to develop a property according to the underlying zoning provisions. However, in order to develop certain uses or certain densities, the overlay provisions kick-in. Overlay zones can also be created

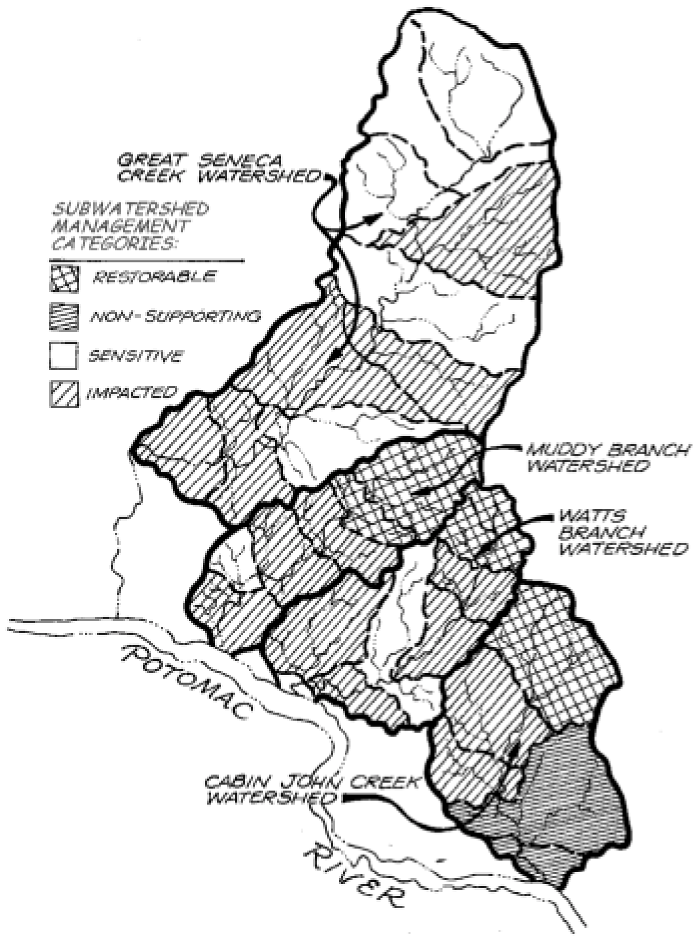

Figure 2: Illustration of the Subwatershed Management Categories for Watershed Planning (MCDEP, 1998)

to protect particular resources such as wetlands, forests, or historic sites. Here the provisions of the overlay zone incorporate mandatory requirements which restrict development in some way to reach the desired end.

Urban Growth Boundaries: This planning technique establishes a dividing line between areas appropriate for urban and suburban development, and areas appropriate for agriculture, rural and resource protection. Boundaries are typically set up for a 10 or 20 year period and should be maintained during of the life of the planning period. Boundaries may be examined at planning period renewal intervals to assess whether conditions have changed since they were established. Boundaries should rarely be changed between planning cycles to ensure a consistent playing field for both the marketplace and citizens.

Urban growth boundaries are sometimes called development service districts, and include areas where public services are already provided (e.g., sewer, water, roads, police, fire, and schools). The delineation of the boundary is very important. There are several important issues to consider in establishing an urban growth boundary. These include the following:

- Public facilities and services must be nearby and/or can be provided at reasonable cost and in a specific time frame.
- A sufficient amount of land to meet projected growth over the planning period must be provided.
- A mix of land uses must be provided.
- The potential impact of growth within the boundary on existing natural resources should be analyzed.
- The criteria for defining the boundary needs to be fair and should consider natural features (versus man-made features) wherever possible. The use of watershed boundaries as the urban growth boundary is one such natural feature.

Large Lot Zoning: This land use planning technique is perhaps most widely used to try to mitigate the impacts of development on receiving water quality. The technique involves zoning land at very low densities to disperse impervious cover over large areas. Densities of one lot per two, five, From the standpoint of watershed protection, large lot zoning is most effective when lots are extremely large (five to 20 acre lots) While large lot zoning does tend to reduce the impervious cover and therefore the amount of stormwater runoff at a particular location, it also spreads development over vast areas. The road networks required to connect these large lots can actually increase the total amount of imperviousness created for each dwelling unit (Schueler, 1995). In addition, large lot zoning contributes to regional sprawl. Sprawl-like development increases the expense of providing community services such as fire protection, water and sewer systems, and school transportation.

Key Land Use Planning Choices for the Watershed Manager

When applying the watershed planning tool, watershed managers need to answer some hard questions relating to land use and watershed planning:

- What are the most economically and politically acceptable land use planning technique(s) that can be used to shift or reduce impervious cover among my subwatersheds?
- How accurate are the estimates of the amount and location of future impervious cover in my watershed? Are better projections needed?
- Will future increases in impervious cover create unacceptable changes to a watershed and/or subwatershed?
- Which subwatersheds appear capable of absorbing future growth in impervious cover?

Tool #2: Land Conservation

While the first tool emphasizes how much impervious cover is created in a watershed, the second tool concerns itself with land conservation. Five types of land may need to be conserved in a subwatershed:

- **Critical habitats** for plant and animal communities
- **Aquatic corridors** along streams and shorelines
- **Hydrologic reserve areas** that sustain a stream's hydrologic regime
- **Water hazards** that pose a risk of potential pollution spills
- **Cultural/ historical areas** that are important to our sense of place

A watershed manager must choose which of these natural and cultural areas must be conserved in a subwatershed in order to sustain the integrity of its aquatic and terrestrial ecosystems, and to maintain desired human uses from its waters. Table 1 includes descriptions and examples of these five conservation areas.

While land conservation is most important in sensitive subwatersheds, it is also a critical tool in other subwatershed management categories. Each subwatershed should have its own land conservation strategy based on its management category, inventory of conservation areas, and land ownership patterns.

The five conservation areas are not always clearly differentiable. Some of the natural areas may overlap among the conservation areas. For example, a freshwater wetland may serve as a critical habitat, be part of the aquatic corridor and also comprise part of the hydrologic reserve areas. However, the bulk of the most critical areas are covered in at least one of these five categories.

Techniques for Conserving Land

Different land management techniques are needed to conserve natural areas. These techniques depend on the type of conservation area and subwatershed being managed. Each subwatershed contains a unique mixture of conservation areas and requires careful choices for land conservation, depending on the goal of the subwatershed plan, geographic region, and stakeholder consensus.

There are numerous techniques that can be used to conserve land which provide a continuum ranging from absolute protection to very limited protection. Some of the major land conservation techniques include:

- Land Acquisition
- Conservation Easements
- Regulate Land Alteration
- Exclusion or Setback of Water Pollution Hazards
- Protection within the Green Space of Open Space Designs
- Landowner Stewardship
- Public Sector Stewardship

Key Land Conservation Choices for the Watershed Manager

When applying the land conservation tool, a watershed manager must make some careful choices about the mix of conservation areas to protect and what techniques to employ. Given the large areas that need to be conserved within some subwatersheds, many different conservation techniques need to be applied to cover the patchwork of public and private lands across a subwatershed.

Some of the land conservation choices a watershed manager often has to make include:

- What fraction of my subwatershed needs to be conserved?
- What are the highest priorities for land conservation in my subwatershed?
- Who will manage these conservation areas over the long-term?

Table 1: Description and Examples of the Five Conservation Areas		
Conservation Area	**Description**	**Examples**
Critical Habitat 	essential spaces for plant and animal communities or populations	tidal wetlands, freshwater wetlands, large forest clumps, springs, spawning areas in streams, habitat for rare or endangered species, potential restoration areas, native vegetation areas, coves
Aquatic Corridor 	area where land and water interact	floodplains, stream channels, springs and seeps, steep slopes, small estuarine coves, littoral areas, stream crossings, shorelines, riparian forest, caves, and sinkholes
Hydrologic Reserve 	undeveloped areas responsible for maintaining the predevelopment hydrologic response of a subwatershed	forest, meadow, prairie, wetland, crop pasture or managed forest
Water Pollution Hazard 	any land use or activity that is expected to create a relatively high risk of potential water pollution	septic systems, landfills, hazardous waste generators, above or below ground tanks, impervious cover, surface or subsurface discharge of wastewater effluent, land application sites, stormwater "hotspots," pesticide application, industrial discharges, and road salt storage areas
Cultural/Historical Reserves 	areas that provide a sense of place in the landscape and are important habitats for people	historic or archaeologic sites, trails, parkland, scenic views, water access, bridges, and recreational areas

Figure 3: A Stream Buffer

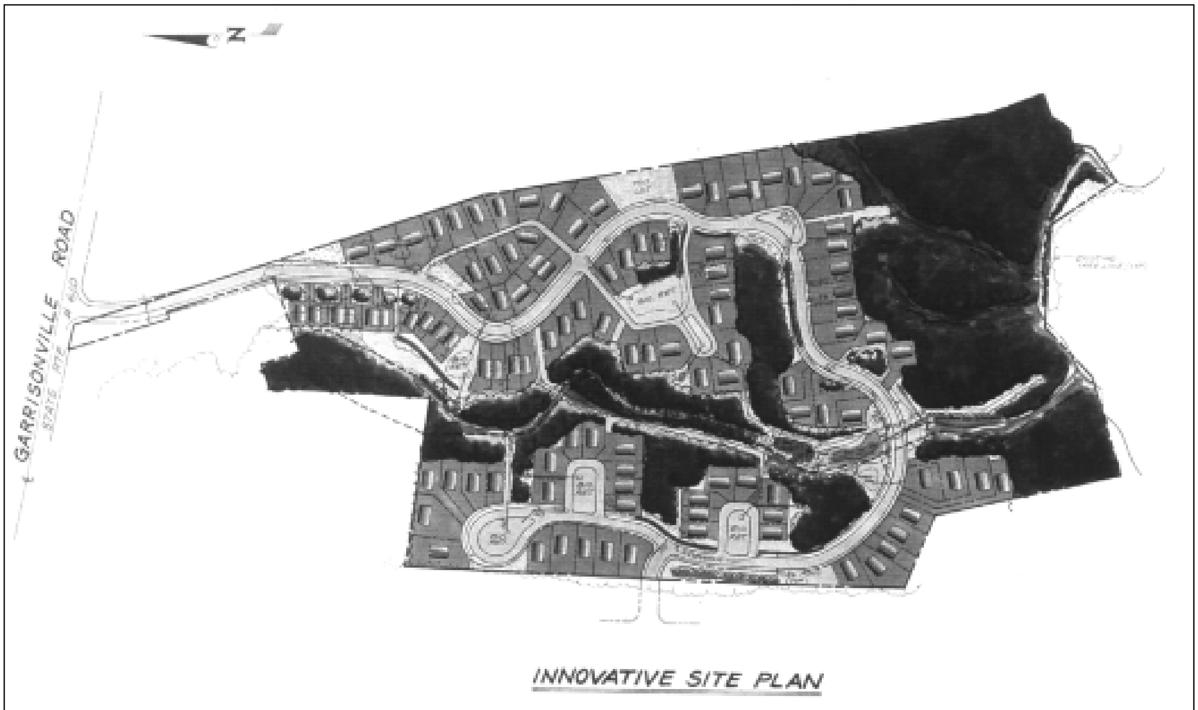

Figure 4: An Innovative Site Plan

In this design, stormwater pollutant loading was reduced by 40%, and the cost of development was reduced by 20% compared to a conventional site.

- What incentives can be used to promote stewardship of private lands?
- Is a land trust available to accept and manage conservation areas, or does one need to be created?
- What are the most appropriate techniques to conserve land in the watershed?
- At what scale and by what method should conservation areas be delineated?

Tool #3: Aquatic Buffers

The aquatic corridor, where land and water meet, deserves special protection in the form of buffers. A buffer can be placed along a stream or shoreline or around a natural wetland. A buffer has many uses and benefits. Its primary use is to physically protect and separate a stream, lake or wetland channel from future disturbance or encroachment. For streams, a network of buffers acts as a right-of-way during floods and sustains the integrity of stream ecosystems and habitats. Technically, a buffer is one type of land conservation area, but it's functional importance in watershed protection merits some discussion on how they work and why they are important.

In some settings, buffers can remove pollutants traveling in stormwater or groundwater. Shoreline and stream buffers situated on flat soils have been found to be effective in removing sediment, nutrients, and bacteria from stormwater runoff and septic system effluent in a wide variety of rural and agricultural settings along the East Coast (Desbonnet *et al.*, 1994). While the benefits of buffers in urban areas are impressive, their capability to remove urban stormwater pollutants is often limited. Urban runoff concentrates rapidly on paved and hard packed turf surfaces and crosses the buffer as channel flow, effectively short circuiting the buffer. Buffers can also provide wildlife habitat and recreation. In many regions of the nation, the benefits of a buffer are amplified if is managed in a forested condition.

The ability of buffers to actually realize the many potential benefits depends on how well the buffer is planned, designed and maintained. Buffers are important because they make up an integral part of the watershed protection strategy and complement other programs and efforts to protect critical receiving water quality.

Key Buffer Choices for the Watershed Manager

When applying the buffer tool, a watershed manager must make some careful choices about which kind of buffers are needed and how wide they must be. In many cases, a new buffer ordinance may need to be adopted or an old one revised to establish an effective buffer network within a subwatershed.

A watershed manager faces many tough questions when designing a buffer program for a subwatershed. Some issues that should be addressed include:

- How much of the aquatic corridor can be protected by buffers in my subwatershed?
- How should buffers be managed and crossed?
- Is restoration or better stewardship possible along an aquatic corridor that has already been developed?
- Will the buffer network be managed as a recreational greenway or as a conservation area in my subwatershed?
- Who will own and maintain the buffer and how will maintenance be paid for?
- How much pollutant removal can realistically be expected from my buffer network?

Tool #4: Better Site Design

Individual development projects can be designed to reduce the amount of impervious cover they create, and increase the natural areas they conserve. Many innovative site planning techniques have been shown to sharply reduce the impact of new development (see Figure 4). Designers, however, are often not allowed to use these techniques in many communities because of outdated local zoning, parking or subdivision codes.

Thus, the fourth watershed protection tool seeks to foster better site designs that can afford greater protection to a subwatershed. The Center has recently developed a guidance manual entitled *Better Site Design: A Handbook for Changing Development Rules in Your Community* (CWP, 1998a) that helps watershed managers identify the local development rules that need to be changed to promote better site designs.

Four better design strategies that have special merit for subwatershed protection include:

1. Open space residential subdivisions
2. Green parking lots
3. Headwater streets
4. Rooftop runoff management

Open Space or Cluster Residential Subdivisions

Cluster development designs minimize lot sizes within a compact developed portion of a property while leaving the remaining portion open. Housing can still be detached single family homes as well as multi-family housing or a mix of both. Clustered development creates protected open space that provides many environmental as well as market benefits. Cluster or open space development design typically keeps 30 to 80% of the total site area in permanent community open space with much of the open space managed as natural area.

The key benefit of open space or cluster development is that it can reduce the amount of impervious cover created by a residential subdivision by 10 to 50% (CWP, 1998b; DE DNREC, 1997; Dreher and Price, 1994; Maurer, 1996; SCCCL, 1995). Clustering can also provide many community and environmental benefits. It can eliminate the need to clear and grade 35 to 60% of total site area and can reserve up to 15% of the site for active or passive recreation. When carefully designed, the recreation space can promote better pedestrian movement, a stronger sense of community space, and a park-like setting. Numerous studies have confirmed that housing lots situated near greenways or parks sell for a higher price than more distant homes. Open space designs provide developers some "compensation" for lots that would otherwise have been lost due to wetland, floodplain, or other requirements. This, in turn, reduces the pressure to encroach on buffers and other natural areas. In addition, the ample open spaces within a cluster development provide a greater range of locations for more cost-effective stormwater runoff practices.

Green Parking Lots

When viewed from the air, parking lots are usually the largest feature of a commercial area, at least in terms of surface area. Over time, local parking codes have evolved to ensure that all workers, customers and residents have convenient and plentiful parking. In this respect, local parking codes have been a great success. One by-product, however, has been the creation of large expanses of often needless impervious cover.

A key strategy to reduce impervious cover involves the construction of green parking lots. Green parking refers to an approach that downsizes parking areas while still providing convenient access for the motorist. Green parking can be achieved through careful design and a comprehensive revision of local parking codes. The common theme in green parking lots is minimization of impervious area at every stage of parking lot planning and design.

Headwater Streets

Since streets are one of the biggest components of impervious cover created by car transport needs, headwater streets are built on a revised classification system where street width declines with decreasing average daily trips (much like headwater streams which decrease in size with decreasing drainage area). This is essential, since streets are a key source area for stormwater pollutants and do not allow the natural infiltration of water into the ground. By revisiting and changing some local subdivision codes many of the traditionally accepted standards can be changed to address this issue.

Rooftop Runoff Management

Re-directing rooftop runoff over pervious surfaces before it reaches paved surfaces can decrease the annual runoff volume from a site by as much as 50% for medium to low density residential land uses (Pitt, 1987). This can significantly reduce the annual pollutant load and runoff volume being delivered to receiving waters and therefore can have a substantial benefit in reducing downstream impacts.

Key Site Design Choices for the Watershed Manager

When using the better site design tool, a watershed manager should be realistic about how much impervious cover can be reduced through better site design in a subwatershed. While better site designs can reduce the impact of individual development projects, the cumulative impact of too much development can still degrade some subwatersheds, no matter how well each one is designed. The value of the site design tool appears to be greatest in those subwatersheds that are approaching their maximum impervious cover limit.

- A watershed manager needs to make some careful choices on how to best promote better site designs within a subwatershed. Some questions include:
- Will better site design really make a difference in reducing the growth of impervious cover in the sub-watershed?
- What are the most important development rules that need to be changed to promote better site design, and can a local consensus be achieved to actually change them?
- What economic and other incentives can be used to encourage developers to utilize better site designs?
- What is the time frame for revising codes and ordinances in the context of watershed planning?

Perhaps the most destructive stage of the development cycle is the relatively short period when vegetation is cleared and a site is graded to create a buildable landscape. The potential impacts to receiving waters are particularly severe at this stage. Trees and topsoil are removed, soils are exposed to erosion, natural topography and drainage patterns are altered, and sensitive areas are often disturbed. A combination of clearing restrictions, erosion prevention and sediment controls, coupled with a diligent plan review and strict construction enforcement are needed to help mitigate these impacts. Many communities rely primarily on sediment control as the primary strategy for sediment loss, though increasingly, the value of non-structural practices for erosion prevention are being recognized (Brown and Caraco, 1997).

Thus, the fifth watershed protection tool seeks to reduce sediment loss during construction and to ensure that conservation areas, buffers, and forests are not cleared or otherwise disturbed during construction.

Key Erosion and Sediment Control Choices for the Watershed Manager

Every community should have an effective erosion and sediment control (ESC) program to reduce the potentially severe impacts generated by the construction process. The watershed manager should play a key role in defining which specific ESC practices need to be applied within the subwatershed to best protect sensitive aquatic communities, reduce sediment loads, and maintain the boundaries of conservation areas and buffers.

- Some of the key decisions that watershed managers often make at the subwatershed level include:
- Is a higher level of ESC practice or more frequent inspection needed to protect my subwatershed?
- How well do current ESC programs reinforce other watershed protection tools, such as buffers, conservation areas, and better site design?
- What incentives can be used to minimize the amount of clearing at development sites?

Tool #6: Stormwater Treatment Practices

A watershed manager needs to make careful choices about what stormwater treatment practices need to be installed in the subwatershed to compensate for the hydrological changes caused by new and existing development. The key choice is to determine what are the primary stormwater objectives for a subwatershed that will the govern the selection, design and location of stormwater practices at individual development sites. While the specific design objectives for stormwater practices are often unique to each subwatershed, the general goals for stormwater are often the same:

- Maintain groundwater recharge and quality
- Reduce stormwater pollutant loads
- Protect stream channels

Open Channel

Stormwater Pond

Stormwater Wetland

Stormwater Filter

Infiltration Trench

Figure 5: Examples of Stormwater Management Practices

- Prevent increased overbank flooding
- Safely convey extreme floods

Stormwater treatment practices are used to delay, capture, store, treat or infiltrate stormwater runoff. There are five broad groups of structural stormwater management practices:

- Ponds
- Wetlands
- Infiltration
- Filtering systems
- Open channels

Some examples of these are provided in Figure 5.

While many advances have been made recently in innovative stormwater practice designs, their ability to maintain resource quality in the absence of the other watershed protection tools is limited (Horner *et al.*, 1996). In fact, stormwater practices designed or located improperly can cause more secondary environmental impacts than if they were not installed at all.

Key Stormwater Choices for the Watershed Manager

Selecting the best stormwater practice can be a real challenge for the watershed manager. Some of the important issues and questions that watershed managers should address include the following:

- What is the most effective mix of structural vs. nonstructural stormwater practices that can meet my subwatershed goals?
- Which hydrologic variables do we want to manage in the subwatershed (recharge, channel protection, flood reduction, etc)?
- What are the primary stormwater pollutants of concern (phosphorus, bacteria, sediment, metals, hydrocarbons, or trash and debris)?
- What are the best stormwater practices for removing pollutants?
- Which stormwater practices should be used or avoided in the subwatershed because of their environmental impacts?
- What is the most economical way to provide stormwater management?
- Which stormwater practices are the least burdensome to maintain within local budgets?

Tool #7. Non-Stormwater Discharges

This tool concerns itself with how wastewater and other non-stormwater flows are treated and discharged in a watershed. In some watersheds, non-stormwater discharges can contribute significant pollutant loads to receiving waters. Key program elements consist of inspections of private septic systems, repair or replacement of failing systems, utilizing more advanced on-site septic controls, identifying and eliminating illicit connections from municipal stormwater systems, and spill prevention.

Three basic kinds of non-stormwater discharges are possible in a subwatershed. Most non-stormwater discharges are strictly governed under the National Pollutant Discharge Elimination System (NPDES), and require a permit.

1. **Septic systems** (on-site sewage disposal) are used to treat and discharge wastewater from toilets, wash basins, bathtubs, washing machines, and other water-consumptive items that can be sources of high pollutant loads. One out of four homes in the country uses a septic system, collectively discharging a trillion gallons of wastewater annually (NSFC, 1995). Because of their widespread use and high volume discharges, septic systems have the potential to pollute groundwater, lakes and streams if located improperly or if they fail. Even properly functioning septic systems can be a substantial source of nutrient loads in some settings. Unlike other non-stormwater discharges, septic systems are not regulated under NPDES, but are approved by local and state health agencies.

2. With **sanitary sewers**, wastewater is collected in a central sewer pipe and sent to a municipal treatment plant. Ideally, this permits more efficient collection of wastewater, and often higher levels of pollutant reduction. The extension of sanitary sewer lines is not without some risk, as it has the potential to induce more development than may have been possible in a watershed that had been previously served only by on-site sewage disposal systems (particularly when soils are limiting). Most communities cannot refuse service to new development within the water and sewer envelope, so the decision to extend lines out into undeveloped areas allow future developers to tap into the line.

In addition, not all sanitary sewer conveyance and treatment systems are capable of achieving high levels of pollutant reduction. Examples include the following:

- Package treatment plants
- Combined sewer overflows
- Sanitary sewer overflows
- Illicit or illegal connections to the storm drain network

3. Wastewater is not the only non-stormwater discharge possible in a watershed. A planner should also investigate whether other non-stormwater discharges are a factor in the subwatershed. Examples include the following:

- Industrial NPDES discharges
- Urban "return flows" (discharges caused by activities such as car washing and watering lawns)
- Water diversions
- Runoff from confined animal feeding lots

Key Non-Stormwater Discharge Choices for the Watershed Manager

One of the first priorities for a watershed manager is to conduct a quick inventory of the nature and extent of non-stormwater discharges in the subwatershed. If non-stormwater discharges appear to be a problem, then a watershed manager may need to conduct a subwatershed survey. This usually involves a survey of the largest or most common wastewater discharges within the subwatershed, with a strong emphasis on how wastewater is actually conveyed within the subwatershed (i.e. sanitary sewer, septic systems, etc.).

- Some issues to address for the non-stormwater discharges tool include the following:
- What, if any, regulating or permit programs can be utilized to improve compliance for the greatest discharges?
- Does it make sense to extend the water/sewer envelope into the watershed?
- Where will the sewer be located in relationship to the stream corridor?
- Are current permit limits adequate or is a higher level of treatment needed?
- Where will the discharge be located?
- What kind of septic siting criteria should be required?
- What kind of septic system technology should be used?
- How will septic systems be inspected, cleaned and maintained?

Tool #8: Watershed Stewardship Programs

Once a subwatershed is developed, communities still need to invest in ongoing watershed stewardship. The goal of watershed stewardship is to increase public understanding and awareness about watersheds, promote better stewardship of private lands, and develop funding to sustain watershed management efforts.

There are six basic programs that watershed managers should consider to promote a greater watershed stewardship:

- Watershed Advocacy
- Watershed Education
- Pollution Prevention
- Watershed Maintenance
- Indicator Monitoring
- Restoration

1. **Watershed Advocacy:** Promoting watershed advocacy is important because it can lay the foundation for public support and greater watershed stewardship. One of the most important investments that can be made in a watershed is to seed and support a watershed management structure to carry out the long-term stewardship function. Often, a grass roots watershed management organization is uniquely prepared to handle many critical stewardship programs, given their watershed focus, volunteers, low cost and ability to reach into communities. Watershed organizations can be forceful advocates for better land management and can develop broad popular support and involvement for watershed protection. Local government also has an important role to play in watershed advocacy. In many watersheds, local governments create or direct the watershed management structure.

2. **Watershed Education:** A basic premise of watershed stewardship is that we must learn two things: that we live in a watershed and that we understand how to live within it. The design of watershed education programs that create this awareness is of fundamental importance. The four elements of watershed education are as follows:

- **Watershed awareness:** raising basic watershed awareness through signage, storm drain stenciling, streamwalks, maps
- P**ersonal stewardship:** educating residents about the individual role they play in the watershed and communicating specific messages about positive and negative behaviors
- P**rofessional training:** educating the development community on how to apply the tools of watershed protection
- W**atershed engagement:** providing opportunities for the public to actively engage in watershed protection and restoration

3. **Pollution Prevention:** Some watershed businesses may need special training on how to manage their operations to prevent pollution and thereby protect the watershed. In some cases, local or state government may have a regulatory responsibility to develop pollution prevention programs for certain businesses and industrial categories (e.g., under industrial or municipal NPDES stormwater permits).

4. **Watershed Maintenance:** Most watershed protection tools require maintenance if they are to properly function over the long run. Some of the most critical watershed "maintenance" functions include management of conservation areas and buffer networks, and maintenance of stormwater practices, septic systems and sewer networks.

5. **Watershed Indicator Monitoring:** An ongoing stewardship responsibility is to monitor key indicators to track the health of the watershed. Public agencies should seriously consider citizen monitoring to provide high quality and low cost indicator data.

6. **Watershed Restoration:** The last phase of watershed stewardship is to restore or at least rehabilitate streams that have been degraded by past development. Urban watershed restoration is an emerging art and science that seeks to remove pollutants and enhance habitat to restore urban streams. The urban watershed restoration process should include three main themes: stormwater retrofitting, source control through pollution prevention, and stream enhancement (Claytor, 1995).

Key Choices for the Watershed Manager

There are several important issues that watershed managers should address when designing watershed stewardship programs:

- Is my community ready to undertake restoration?
- Which mix of stewardship programs is best for my subwatershed?
- Who are the best targets for watershed education?
- How am I going to pay for a stewardship program?

Summary

This article provides a simple introduction to the eight watershed protection tools. For more information on how to implement these tools, refer to other articles in this book.

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