Principles of Watershed Management

NOTICE: This PDF file was adapted from an on-line training module of the EPA's ***Watershed Academy Web***, found at http://www.epa.gov/watertrain. To the extent possible, it contains the same material as the on-line version. Some interactive parts of the module had to be reformatted for this noninteractive text presentation. Review questions are compiled at the end of the file as a self-test.

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Welcome to the Principles of Watershed Management module. This module has four main purposes. It should increase understanding of:

1. basic watershed processes and their interrelated nature,
2. the principles of long-term watershed management,
3. the elements of successful watershed management frameworks, and
4. the benefits of the watershed management approach.

Watershed management approaches are evolving throughout the country and are being used to solve tough problems. On the following pages are 6 examples of successful watershed management cases. Based on successful watershed management efforts like these across the country, this tutorial presents four core principles of watershed management:

1. Watersheds are natural systems that we can work with.
2. Watershed management is continuous and needs a multi-disciplinary approach.
3. A watershed management framework supports partnering, using sound science, taking well-planned actions and achieving results.
4. A flexible approach is always needed.

SIX SUCCESSES IN WATERSHED MANAGEMENT

Merrimack River Initiative, New England:

Public and Private Partners Collaborate to Build Watershed Toolbox to Aid Management Decision-Making

In New England, the Merrimac River Initiative has brought together the States of New Hampshire and Massachusetts with USEPA and the NE Interstate Water Pollution Control Commission to collaborate on water quality issues. This has resulted in many joint projects and successes, some of which are collectively referred to as the Watershed Toolbox (Figure 1). These tools not only aid management decision-making and implementation but also make it easier for partners to communicate.

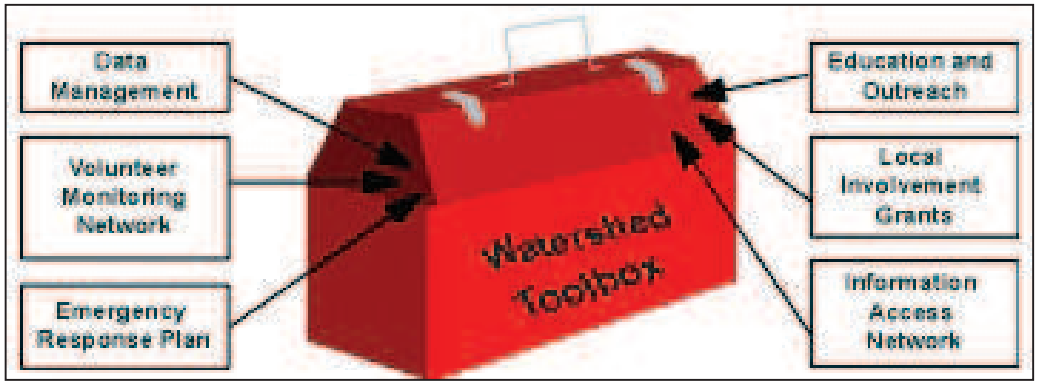

Figure 1: The Watershed Toolbox that helps Merrimack partners work together to address water quality issues.

Boulder Creek, Colorado Watershed Project:

Restoring Multiple River Corridor Values and Uses by Choosing Most Cost-Effective Strategies

A local wastewater treatment plant was targeted for an expensive upgrade to reduce nitrate levels believed to be responsible for an ammonia toxicity problem in Boulder Creek. Intensive-survey monitoring of Colorado's Boulder Creek indicated a number of other factors could be contributing to the decline of the diverse fish populations from the Creek's mountain canyon to its high plains. For example, stream monitors found stream habitat so degraded that it was unsuitable for most forms of aquatic life and could be contributing to the buildup of toxic concentrations of ammonia in the water. A physical habitat restoration program was undertaken to restore the complexity of the stream channel, stabilize the streambanks, revegetate the riparian corridor, create buffer strips to reduce agricultural and grazing runoff, and rebuild diversion and return flow structures to minimize impacts on aquatic habitat. Because of limited funding, key portions of the channel were prioritized and targeted for restoration. The BMPs, habitat restoration, and scaled-back point source nutrient control program were successful in reducing ammonia toxicity problems and revitalizing fish populations in the Creek. Boulder Creek now provides the primary corridor for an urban natural area park system (Figure 2).

Figure 2: Habitat restoration helped reduce ammonia toxicity problems in Boulder Creek.

Occoquan Water Supply Protection:

Looking at Best Use of Land Throughout Watershed, Local Governments Meet Multiple Objectives

In the mid-eighties, several counties in the rapidly urbanizing area of Virginia developed a comprehensive land use plan for the Occoquan Reservoir watershed and adopted zoning ordinances regulating the location, type, and intensity of future land uses. This was done after maximizing the limits of treatment technology for the wastewater treatment plants discharging into the tributaries upstream of the reservoir and after intensive data collection and model development. Fairfax County took the lead in working with basin partners to study different land use development scenarios and how well they met multiple objectives such as:

- improved transportation system
- economic development
- efficient provision of community services, and
- no degradation of the Occoquan water supply.

Depending on the sensitivity of land areas in meeting specific objectives, portions of the watershed were strategically upzoned and others downzoned (Figure 3).

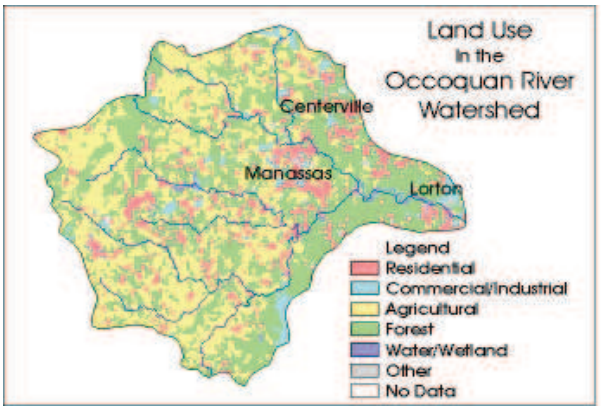

Figure 3: Governments designed zoning ordinances to protect water quality in a rapidly urbanizing watershed.

North Carolina Statewide Framework:

Innovative, Cost-effective Solutions Through Partnerships and Leveraging

North Carolina's statewide basin management approach has resulted in more innovative, cost-effective management. In the Tar-Pamlico River Basin, the state water quality management agency, a consortium of municipal and industrial discharge permittees, a local environmental organization, a national environmental advocacy group, and the state's soil and water agency forged a partnership to implement a pollutant trading program. The discharger consortium agreed to fund development of tools to evaluate management alternatives, and provide cost-share funds to implement agricultural best management practices in lieu of more costly nutrient removal processes at the wastewater treatment facilities (Figure 4). The process was driven by the realization among these parties that point source controls alone could not solve the problems of most concern, and that forcing more restrictive point source controls would only yield marginal returns on investment.

Figure 4: Municipal and industrial permittees achieve water quality goals by funding the implementation of agricultural best management practices in lieu of more costly nutrient removal processes at their facilities.

Cooper River Corridor Project:

Corporate Community Takes the Lead in Ecological Restoration

In 1992, three major chemical companies (Amoco, Dupont, and Bayer) took the lead in forming the Cooper River Corridor Project—a coalition of the US Fish and Wildlife Service, the Wildlife Council, South Carolina's Department of Environmental Protection, citizens, and local corporations—to identify and solve ecological problems in the region. The group first decided to identify weaknesses in a five square mile area of the watershed, looking particularly at the habitat of two endangered animal species, two bird species, the longleaf pine, and sweetgrass (a native grass important to an historical basket weaving cottage industry in the area) (Figure 5). The Project has begun a longleaf pine reforestation program and Amoco planted sweetgrass on many acres of its local land (which regenerated sweetgrass and also the local basket making industry). With these successes in working together, the Project, led by Amoco, is beginning a grass roots community strategic planning process for the entire Cooper River Watershed to protect and restore ecosystems and to strengthen local economic opportunities.

Figure 5: Corporations involved in the Cooper River Corridor Project identified the need to restore habitat.

Washington Statewide Framework:

Improved Database to Support Decision Making

The State of Washington has implemented a statewide watershed approach. The State's framework is designed to improve the basis for decision-making, for both regulatory and nonregulatory programs. Watershed teams with representatives from different participating programs meet with stakeholders in the basin to identify information needs and develop a strategic data collection plan. The result is a common database (Figure 6) that enables stakeholders to target their efforts to the most effective actions.

Figure 6: A statewide database enables stakeholders to make informed decisions and implement effective actions.

CORE PRINCIPLES OF WATERSHED MANAGEMENT

Core Principle 1:

Watersheds are natural systems that we can work with.

Delineating the Watershed

A watershed is simply the land that water flows across or through on its way to a common stream, river, or lake (Figure 7). A watershed can be very large (e.g. draining thousands of square miles to a major river or lake or the ocean), or very small, such as a 20-acre watershed that drains to a pond. A small watershed that nests inside of a larger watershed is sometimes referred to as a subwatershed (Figure 8).

You can delineate a watershed (or many watersheds) on a USGS topographic map using two important map symbols: the blue hydrographic lines symbolizing water and the brown elevation contour lines indicating areas of equal height above sea level. Since water flows downhill from higher elevations to a common body of water, to delineate the watershed boundary for a particular place on a stream or lake, you will need to draw a line along the ridgetops connecting the highest elevation points surrounding the lake or stream. Delineating the ridgeline on a topo map is actually more challenging than you might first imagine!

Figure 7: A watershed is all the land that water flows across or through on its way to a specific stream, river, or lake.

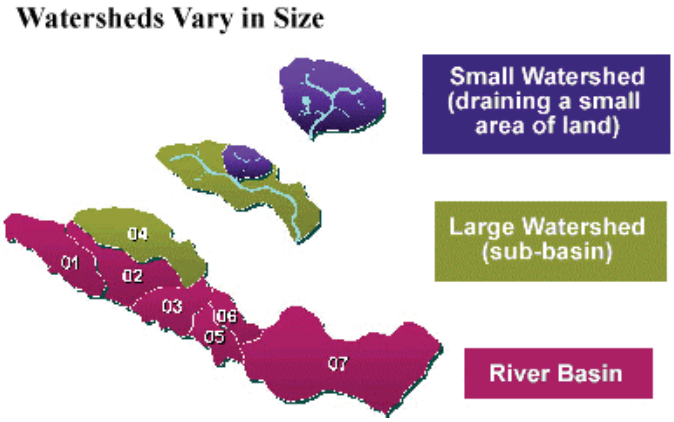

Figure 8: A small watershed inside a larger one is sometimes referred to as a subwatershed.

Fortunately, there are maps and computer databases you can turn to that have watershed boundaries already delineated—particularly for larger basins and watersheds. One popular source is Surf Your Watershed found on the Internet's World Wide Web at http://www.epa.gov/surf. So let's do some surfing - the following images simulate a visit to the Surf Your Watershed website. After you enter this website, one way to find the watershed boundary for the area you're interested in is to click on the appropriate state on the US map (Figure 9).

Once the state map appears, you can click on the area of the state you're interested in (Figure 10). What pops up is the watershed boundary with major streams, lakes and cities in the watershed highlighted (Figure 11).

Find a blue line anywhere on the map and follow it upstream or downstream; soon you hit a junction with another stream called a *confluence* (Figure 12). The lowest junction is called the mouth or outlet of the watershed.

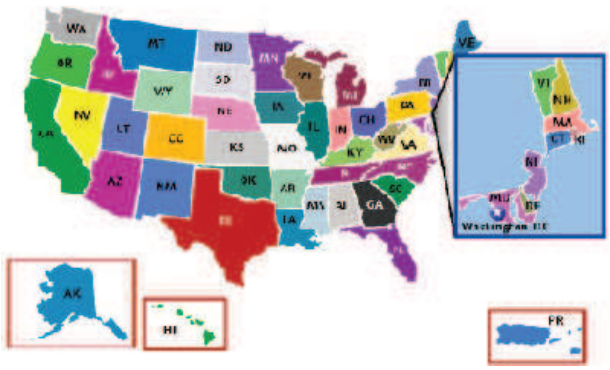

Figure 9: The Surf Your Watershed web site.

Figure 10: In the Surf web site, watersheds are organized by state.

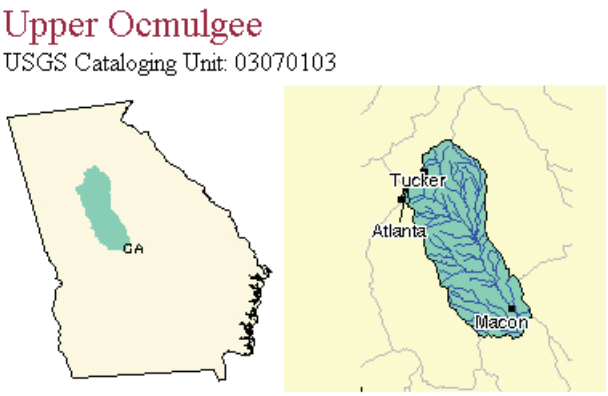

Figure 11: Subwatersheds in each state can be identified.

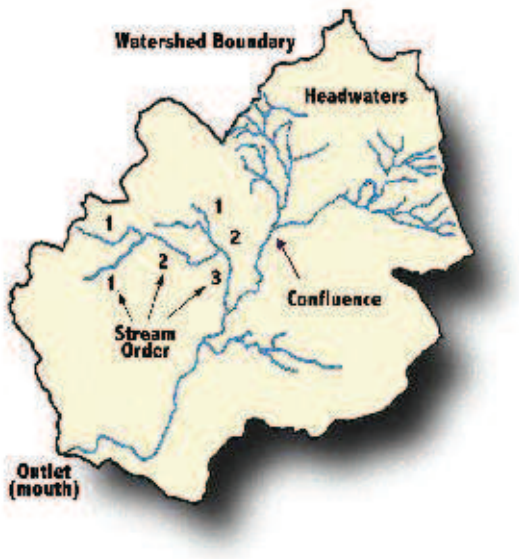

Figure 12: Key map information for watershed management includes the watershed boundary and the network of streams involved in drainage.

Follow one of the blue lines until it ends near a ridge top marking the watershed boundary. Now, let's explore what you find within the watershed boundary. The places where surface waters first begin flowing are called *headwaters*. Some experts like to categorize the hydrography or water bodies within a watershed by a classification system referred to as stream order. For example, when a stream first begins, it is called a first order stream. When two first-order streams join, the water below the junction is called a s*econd order stream*, etc. In this classification system, the next higher order stream is formed when two of the immediately lower order streams have joined.

We often talk about three management zones when discussing watershed management—the *waterbody*, *riparian*, and *upland zones* (Figure 13). Waterbody is a term that includes any stream, river, pond, lake, estuary or ocean. The riparian zone is defined as the non-cultivated, vegetated area between the waterbody edge and the upland area. Riparian means "of the river" and the riparian zone is intimately connected with the waterbody. This zone often includes, but is not limited to, wetlands bordering waterbodies. The upland area is not an exact term, but usually is defined as the land above a high water mark (e.g. 100 year flood plain).

Figure 13: The waterbody channel, riparian zone, and upland zone are three zones referred to when discussing watershed management.

Natural Processes at Work in the Watershed

Importantly, no matter where we live or work, we are in a watershed teeming with unique, inter-related natural processes. These natural forces help shape the watershed landscape, its water quality, and—in turn—our lives.

In mountain upland areas, there are unique blends of climate, geology, hydrology, soils, and vegetation shaping the landscape, with waterways often cutting down steep slopes. Look closely at this picture and the many things that influence water quality: chemicals from the mineral weathering of rocks, from the decay of vegetation, and from groundwater.

Notice how the vegetation shades the water, influencing temperature and what can live in the water (Figure 14). In an upland plains area (Figure 15), you find grassy plains, hardy vegetation, and slower moving, meandering streams and rivers. In the coastal area (Figure 16), where oceans meet land, there are again different blends of features and processes shaping the environment. In lowland areas between upland and coastal waters, where tidal wetlands are prevalent, processes serve entirely different functions.

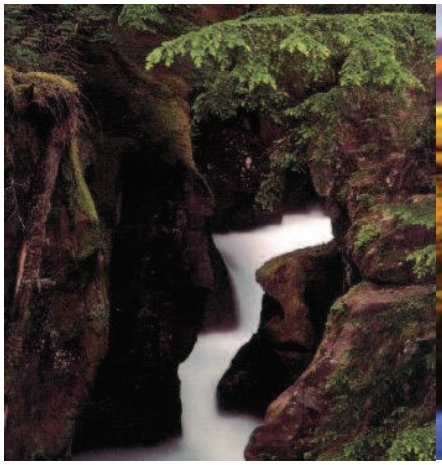

Figure 14: In the mountains, waterways often cut down steep slopes.

Figure 15: Slow moving streams and rivers are often found in the plains.

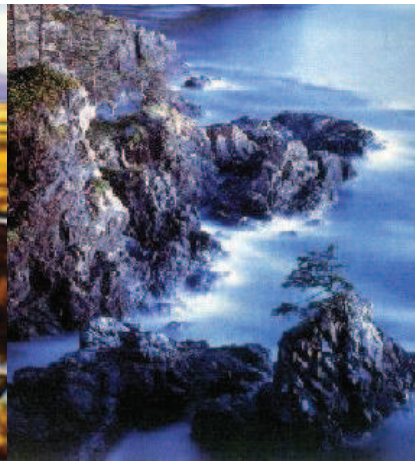

Figure 16: Natural processes are continually reshaping coastal areas where oceans meet land.

In other words, each watershed—indeed each watershed zone—has unique living and nonliving components that interact, with one element responding to the action or change of another. Knowing your watershed means coming to learn the natural processes working within the watershed boundaries.

Once you better understand these processes, you can better appreciate how the watershed's ecological processes help sustain life. Figures 17-20 show some examples of how healthy watersheds sustain life.

Figure 17: Habitat for fish and other life.

Figure 18: Growing our food supply places major demands on available water.

Figure 19: Temporary living quarters for migratory birds.

Figure 20: Drinking water supply costs depend on water availability and necessary treatment

Other benefits of healthy watersheds are shown in Figures 21-23.

⇐ Figure 21: Purifying air of contaminants our communities emit.

⇒ Figure 22: Transporting goods and people.

⇓ Figure 23: Assimilating contaminants that enter the water.

Some natural processes or forces provide benefits to some parts of the watershed while impacting others—at least in the short term. For example, floods replenish soils in the flood plain, but people and other living organisms may be impacted (Figure 24).

Figure 24: Floods can severely impact the lives of people and organisms living in floodplain areas.

Human Factors at Work

Working with your watershed also means understanding how most human activities in the watershed can occur in harmony with natural processes. Communities located along streams and rivers, for example, are faced with very basic choices: they can learn how the river functions and learn to draw benefits from it while staying out of harm's way—or, they can try to significantly change the river's behavior in order to accomplish their plans. It may be feasible to change the way a river acts, but this usually means taking on costly and never-ending maintenance of those man-made changes; and, despite all the maintenance, communities may remain still vulnerable to floods and other disasters. In contrast, a community that has made sensible decisions on activities near the river can avoid a costly maintenance burden while sustaining their community's use and enjoyment of a healthy river system. In which type of community would you rather live and pay taxes?

Understanding Your Watershed

How do you get oriented to what's happening in your watershed? Again, one place to begin a simple screening for potential stressors is Surf Your Watershed (Figure 25). After choosing the watershed you're interested in, the first page summarizes important statistics that describe the watershed such as:

- size of the watershed
- population
- current land uses by percentages
- counties in the watershed

Figure 25: The Surf Your Watershed web site can help you get oriented to what's happening in your watershed.

When online clicking on the words highlighted in blue on this page, you can get more detailed information about potential water quality or habitat stressors in the watershed. For example, you can find out what NPDES (PCS) Facilities (Figure 26) or Toxic Release Sites (Figure 27) are in the watershed.

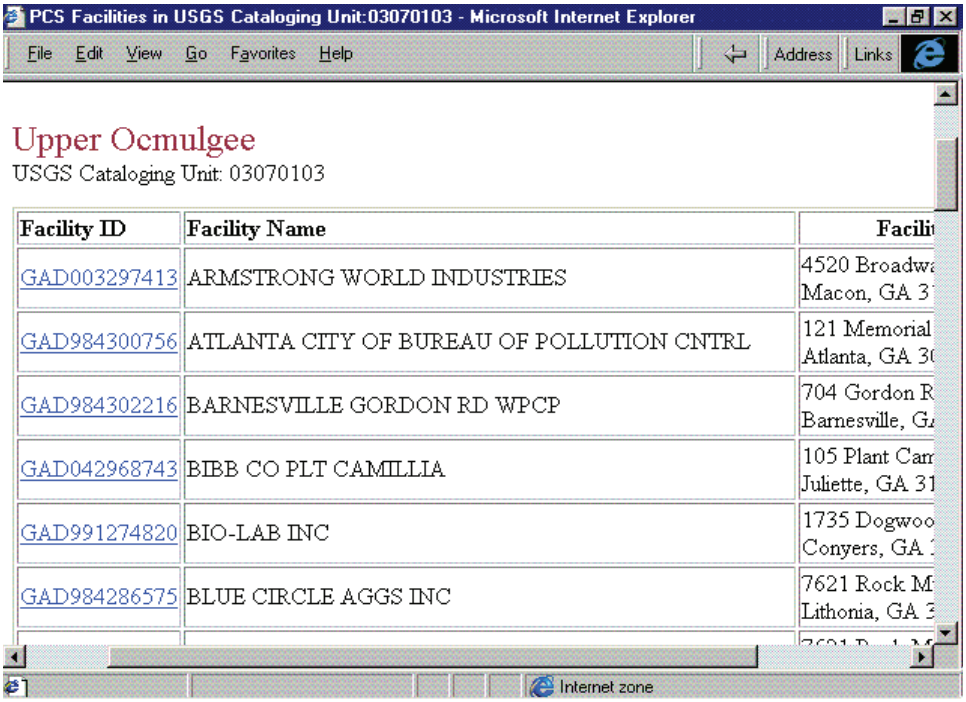

Figure 26: Information on NPDES facilities is listed for each watershed highlighted on EPA's Surf Your Watershed web site.

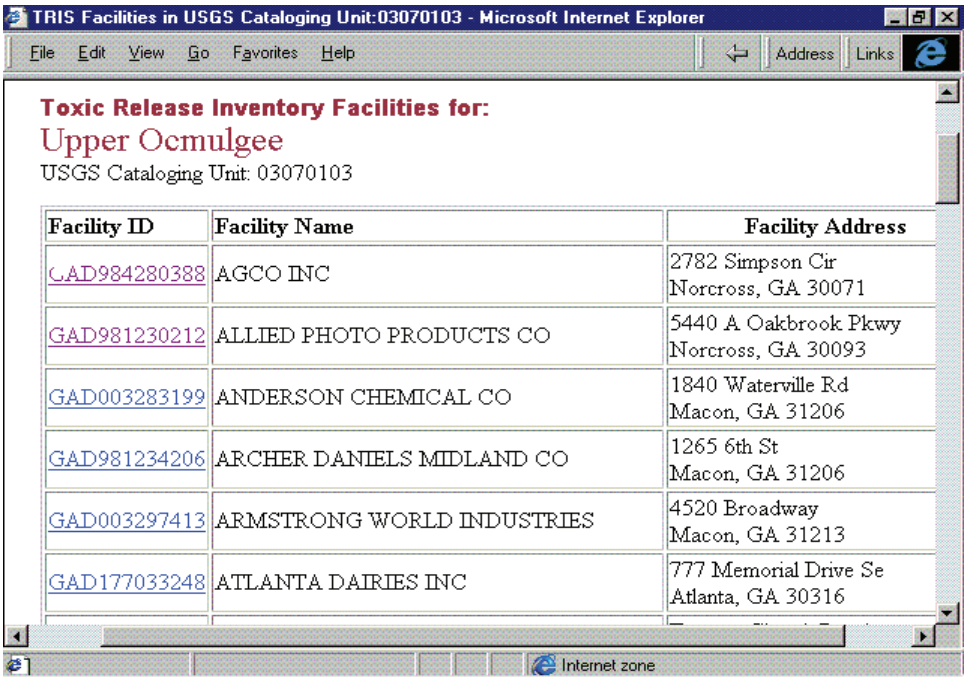

Figure 27: Toxic Release Inventories are also available for each watershed highlighted on EPA's Surf Your Watershed web site.

If you want to understand where these and other potential stressors are in the watershed, you query the database for information such as:

- Population density
- Major roads
- Drinking water supplies
- NPDES sites,
- Toxic Release Sites
- Superfund Sites

BASINS software can then be used to produce maps spatially illustrating this information (Figure 28). BASINS is a multipurpose environmental analysis system developed for EPA to assist regional, state, and local agencies in performing watershed- and water quality-based studies. BASINS integrates a geographical information system (GIS), national watershed data, and modeling tools into one powerful package.

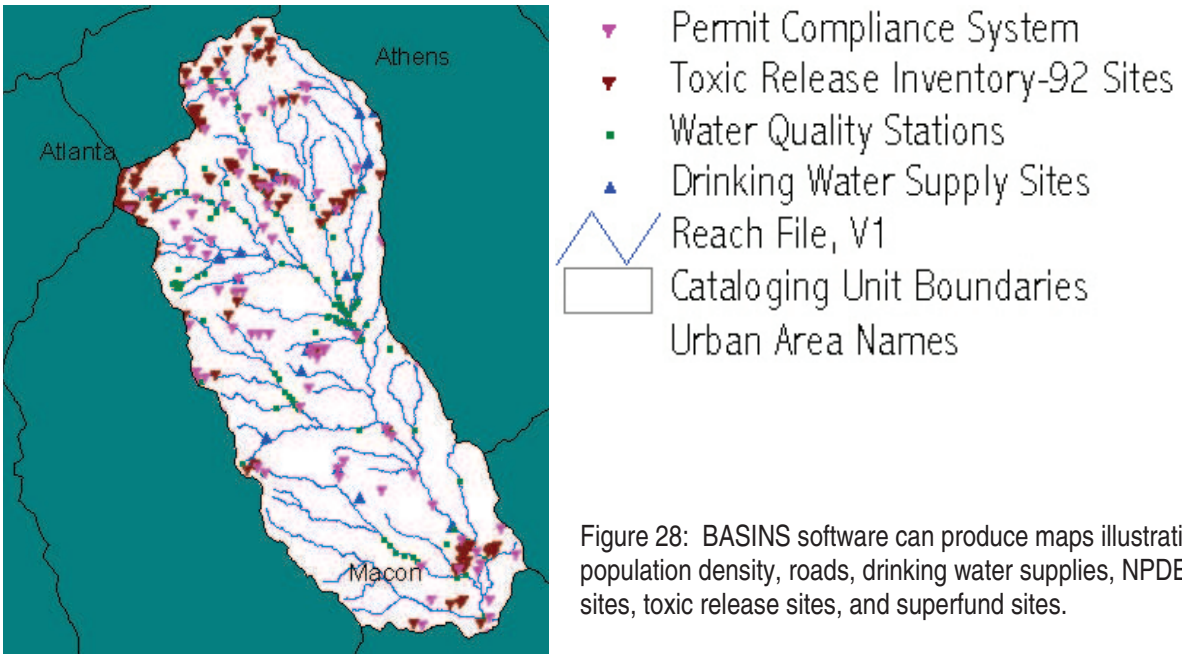

Figure 28: BASINS software can produce maps illustrating population density, roads, drinking water supplies, NPDES sites, toxic release sites, and superfund sites.

Maps and other valuable sources of land use and land cover information may be available through your local government offices. You can also turn to a USGS topo map to get a sense of where the farm, mining, and forest land is in the watershed.

Why is it important to know about these human activities and where they occur in the watershed? **These human forces interact with the natural forces to directly shape the condition of the land and water**. For example,

- increasing impervious surfaces in the urban areas leads to increased water and contaminant runoff;

- removing vegetation along drainage areas and increased stormflows lead to erosion of soils which can change the landscape to more arid conditions;
- increasing the velocity of the water and contaminants it contains can be lethal to living things
- or it can create health hazards, reducing our quality of life.

Once you've conducted a simple screening for potential stressors, you have a better sense of where to do more in-depth investigations, including getting out in the watershed to conduct stream walks, windshield surveys, and strategic water quality sampling.

So watersheds are natural systems we can work with because

- They are practical, tangible management units that people understand, and
- They help us understand and appreciate nature's interrelated processes and how our actions can be tailored to complement rather than impact them.

Core Principle 2:

Watershed Management is continuous and needs a multi disciplinary approach.

In trying to solve environmental problems or prevent them from happening, we have set water quality standards, local water supply antidegradation goals, natural heritage conservation goals, etc. (Figure 29). These goals and standards—usually set by programs within government agencies or different policy making boards—a have been important in developing regulations and in serving as indicators.

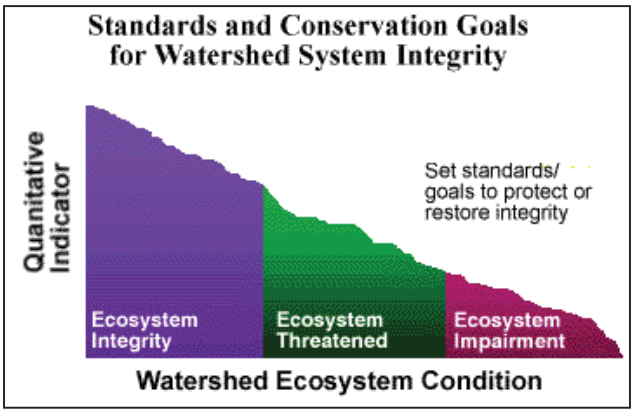

Figure 29: Setting water quality standards can help solve environmental problems and prevent water quality degradation.

Unfortunately, we don't have a natural system barometer to hang outside our window that gives us a direct measure of existing conditions. Instead, we must choose multiple indicators (chemical, biological, and physical) that can help us indirectly gauge overall system integrity.

Many agencies have found the need for a more integrated approach to assessing conditions and developing management strategies (Figure 30). Although they have made progress through existing regulations and programs, they're now faced with solving more thorny environmental problems that cut across programs and jurisdictions (Figure 31). Particularly vexing are nonpoint source pollution and habitat degradation.

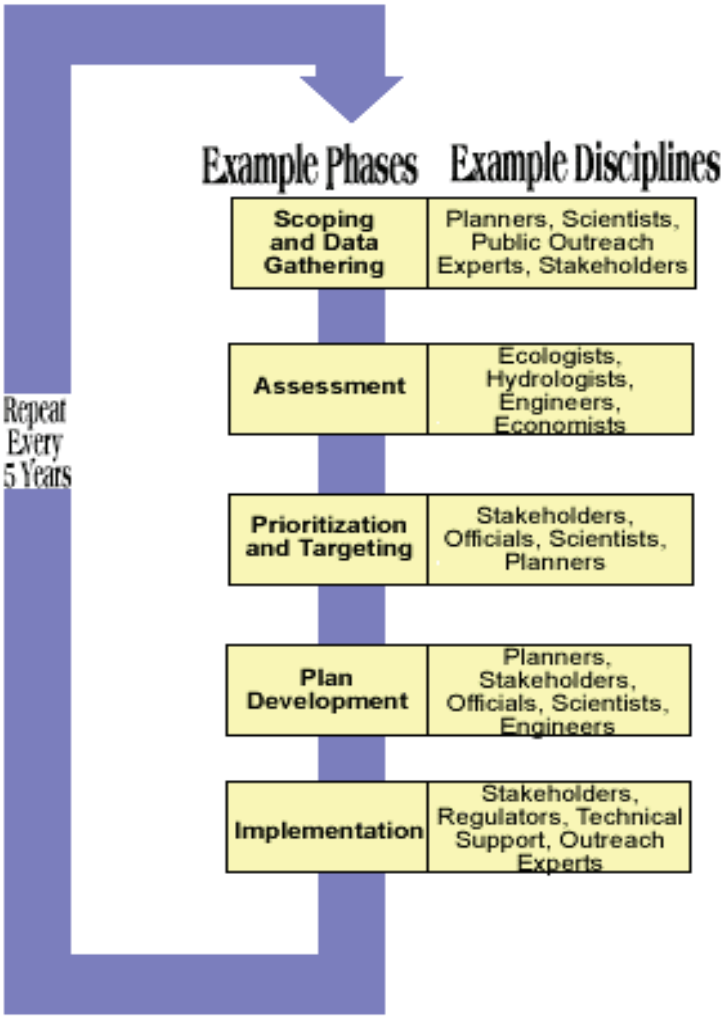

Figure 30: Environmental problems that cut across jurisdictions require an integrated approach to problem solving.

Indeed, many management agencies and organizations are realizing that effective resource management is

- never ending
- involves those affected by decisions
- reflects the integrated nature of nature itself

Watersheds are practical for integrating these efforts. The emerging watershed framework builds on existing management programs and resources but has as its goal watershed system the watershed's integrated system, people start thinking out of the programmatic or organizational boxes and start asking themselves, "What are our common goals?"

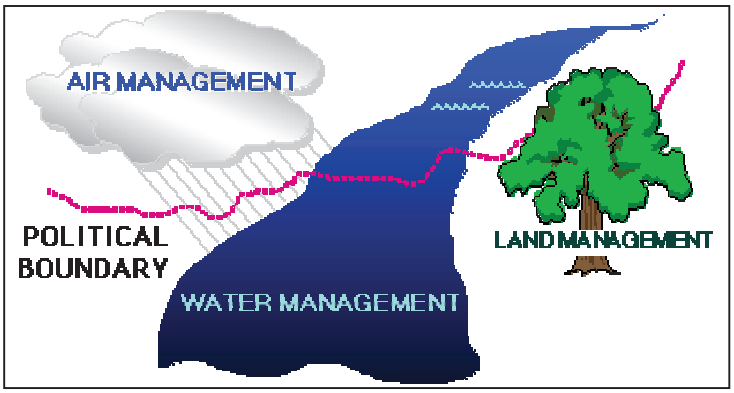

Figure 31: Current environmental problems require solutions that cross both management agency and political boundary lines.

Before we explore this emerging watershed management framework, let's define exactly what we mean by "framework" (Figure 32). A watershed framework is simply a lasting process for partners working together. It's a support structure making it easier to coordinate efforts—a structure made of agreed upon standard operating procedures, timelines, and forums for communicating with each other.

Figure 32: A watershed framework is a support structure that makes it easier for partners to work together.

This is different than a watershed management plan that describes environmental problems, outlines specific restoration and protection actions, and documents where and how actions will be taken and by whom (Figure 33).

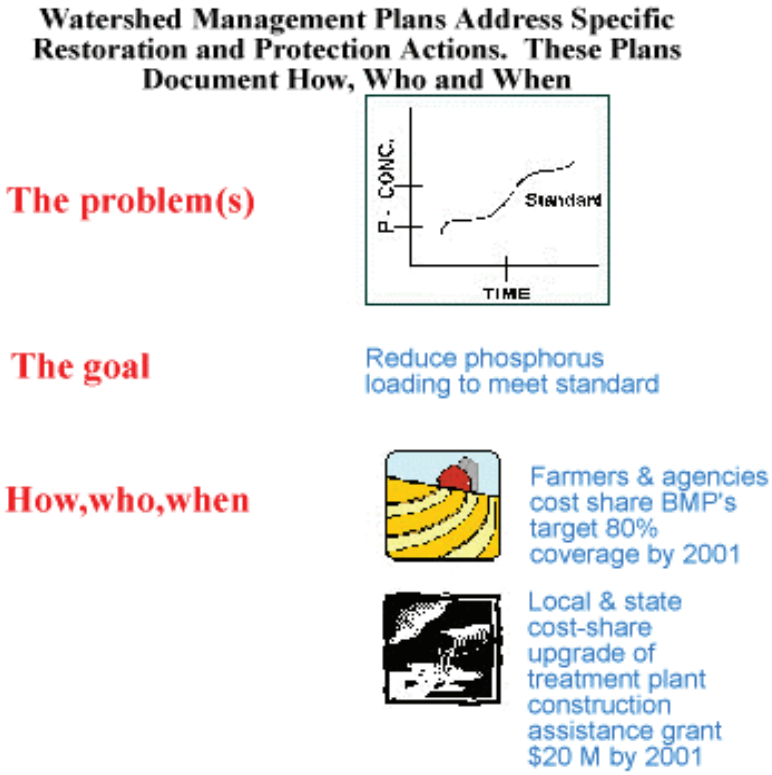

Figure 33: A watershed management framework provides for a lasting process of working together. This is different from a watershed management plan that describes problems and sets restoration goals.

Essentially a coordinating management framework leads to coordinated management plans (Figure 34).

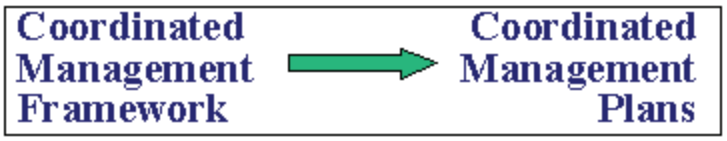

Figure 34: The framework supports coordinated plans.

The emerging framework isn't one size fits all. It takes as a given that you often need to work at different geographic scales, weigh multiple management objectives, and address unique local concerns.

A state agency might be interested in major river basins since it's charged with assessing and managing water quality statewide. A local government wanting to protect its drinking water supply may need to work with neighboring jurisdictions throughout a medium sized watershed. A federal agency may need to implement a multiple use management plan on a watershed in public ownership. A local watershed association may be trying to solve a sedimentation problem in a small watershed. If designed well, the watershed approach links all these initiatives with state, local, and regional frameworks complementing and strengthening each other and individual projects (Figure 35).

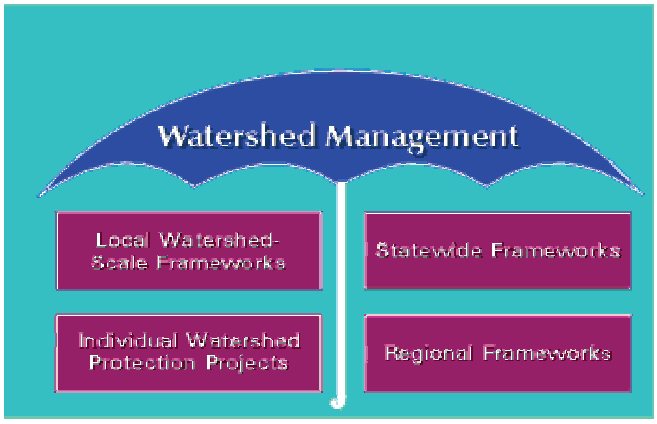

Figure 35: Many different frameworks can be linked under the umbrella of watershed management.

Core Principle 3:

A watershed management framework supports partnering, using sound science, taking well-planned actions, and achieving results.

When you're designing a house, you first think about all the functions you want it to serve. The same is true for designing a watershed management framework. A strong watershed framework

- uses sound science
- facilitates communication and partnerships (Figure 36)
- fosters actions that are well-planned and cost effective
- stimulates actions and tracks results

Figure 36: A watershed management framework facilitates communication between partners.

In looking at watershed management efforts across the country, there are three common elements of successful watershed management frameworks (Figure 37). At the center, 'geographic management units' are the watersheds themselves. Partners agree upon a common set of units (i.e., watersheds) to provide a functional, practical basis for integrating efforts. Stakeholders are involved throughout the process, with clearly defined roles and responsibilities. When we say stakeholder we mean anyone who can impact or is impacted by a decision in the watershed. There are two general categories of stakeholders: first, there are those people who work together on a daily or weekly basis. We call these people watershed partners. Then there are some citizens who live and work in the watershed who just want to be consulted and to provide input periodically. Partners agree on a management cycle, including activities they will work on together and a fixed time schedule for sequencing these activities. Importantly, the cycle signals that watershed management is a never ending job.

Here are some typical steps in a watershed or basin management cycle. Remember, these steps can be initiated by a local watershed association, basin group, or state agency. (Figure 38)

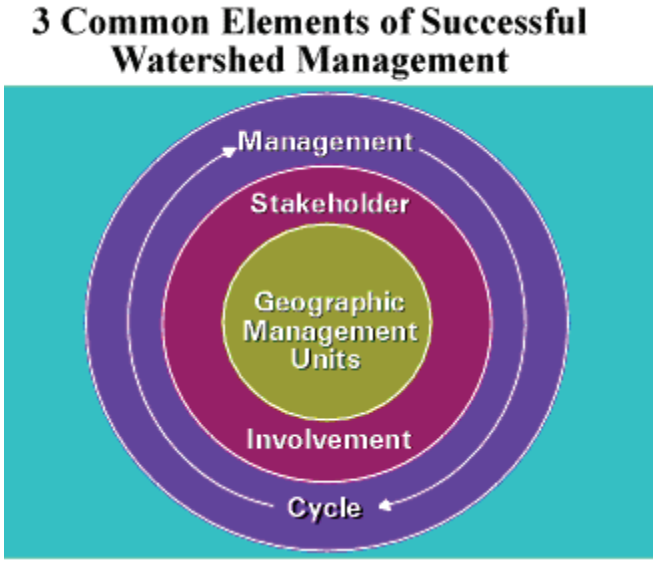

Figure 37: An analysis of watershed management efforts across the country revealed some common elements of successful watershed management.

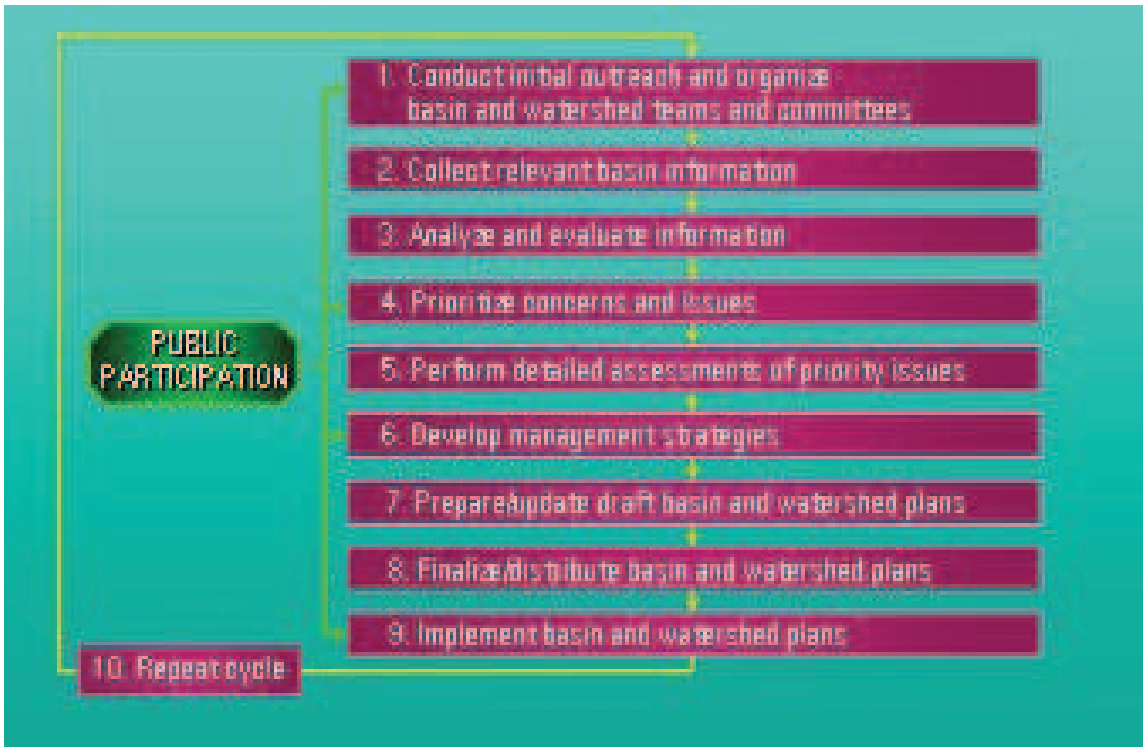

Figure 38: Steps in a basin management cycle can be initiated by a local watershed association, basin group, or state agency.

Some key features of this cycle are:

- it's repeated at fixed intervals (usually five years)
- it acknowledges change. The aim is not the perfect plan, but doing what you can do this cycle knowing you can address other issues in the next cycle
- there is public input all along the way
- it takes a triage or strategic approach to watershed management, using strategic monitoring and assessment to make the most of limited resources
- every step is aimed at taking action and tracking results

Does it sound like a simple cure all or panacea? It isn't! There will always be crisis and new issues that you will need to respond to immediately. And, of course, there are management responsibilities—like spill response and responding to a new permit application—that shouldn't be synchronized with this time cycle. And, yes, coordination takes time. The key question to ask in designing a watershed management framework is: *Does this element of the framework make our job more effective and more efficient?*
That leads us to the last core principle.

Core Principle 4:

A flexible approach is always needed.

The true meaning of this final core principle is that one should never look for a rigid, step-by-step "cookbook recipe" for watershed management. One size does not fit all—different regions of the country have watersheds that function in very different ways, and even neighboring watersheds can have major differences in geology, land use, or vegetation that imply the need for very different management strategies (Figure 39). Different communities vary in the benefits they want from their watersheds. Moreover, watersheds change through time. Eastern watersheds cleared of their forests in the first half of the 20th century had specific management needs during regrowth in the second half of the century, but management needs will likely change again in the 21st century. Changes can even occur on more immediate time scales, due for example to the appearance of a serious forest pest or disease, a change in water use patterns, or the arrival of a new community industry or enterprise. Watershed management is a dynamic and continually readjusting process that is built to accommodate these kinds of changes.

Figure 39: A flexible watershed management approach is needed because watersheds may range from total wilderness to intensively developed.

Let's review the four core principles:

1. Watersheds are natural systems that we can work with.
2. Watershed management is continuous and needs a multi disciplinary approach.
3. A watershed management framework supports partnering, using sound science, taking well-planned actions and achieving results.
4. A flexible approach is always needed.

Benefits of a Watershed Approach

Now take a few minutes to think about how operating with these principles could benefit your watershed management efforts and make your responsibilities easier.

Here are some benefits others have found who have used the watershed approach:

1. It provides **a context for integration**
   - using practical, tangible management units that people understand
   - focusing and coordinating efforts
   - finding common ground and meeting multiple needs
2. It provides a **better understanding and appreciation of nature**
   - understanding nature's interrelated processes
   - helping answer the question, "What are we trying to protect?"
   - linking human activities to nature's response
   - appreciating how nature's processes can benefit people
   - identifying ways we can work with watershed processes
3. It yields **better management**
   - generating ecologically-based, innovative, cost-effective solutions
   - forging stronger working relationships
   - supporting consistent, continuous management

A self-test to assess your comprehension is included on the next page of this module.