THE WATERSHED BOOK

A citizen's guide to healthy streams and clean water

Cuyahoga River
Community Planning Organization

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Cuyahoga River Community Planning Organization, Cleveland, Ohio 44114
A 501(c)3 nonprofit organization dedicated to the restoration and protection of the Cuyahoga River and the Cuyahoga River Remedial Action Plan Area of Concern.

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The Watershed
A Place and a System

Introduction

We all tend to think we know what the implications will be of the decisions we make. And we usually do, at least locally, personally and in the short term. But most of us were never taught to think in terms of the potential effects of our actions on places even a few miles down the road, or people just a generation away. Those who make decisions for our communities are rarely trained in environmental science, yet are called upon to make decisions about land use and planning, where one can build and where one cannot, and all manner of activities that do have short and long-term, local and distant implications.

Most citizens weren't trained in natural processes either, so are at a loss to know if the decisions their leaders are making are good or bad. We do what seems to be generally accepted by the rest of our culture, out of habit or expedience, assuming that if it's not a good thing to be doing there will be a law against it. For example, if my neighbor applies fertilizer and weed killer to his lawn on a regular basis, and waters it thoroughly, he can expect that his grass will be green and weed-free. He's happy, our other neighbors are happy, and that's how people have been taking care of lawns his whole life, so how could it be wrong?

It turns out that this neighbor doesn't test the soil to see if it needs fertilizing, to be sure that the plants absorb all the nutrients, he just applies it on the theory that if a little is good more is better, which is also his watering mode. Once he turns his back, though, and sets the sprinklers going, and the excess fertilizer washes off his lawn and into the storm drain, his actions, combined with those of all the other well-intentioned lawn owners in town, can set in motion a series of events that can have a profound effect on the health of major streams, rivers, and, if he lives in the Great Lakes watershed, on our country's largest supply of fresh water.

Did this person intentionally wash his extra nitrogen, phosphorous and potassium into the storm drain knowing it would wind up in the lake and there create great colonies of algae that would then decompose, consume all the oxygen in the area and leave behind a dead zone where fish can't live, as well as an overabundance of phosphorous? Of course not. He was just taking care of his lawn. On a small, localized scale, he was aware of, and making decisions in the best interest of, his immediate need for a green lawn. He wasn't aware of, or making decisions in the best interest of hundreds of thousands of people who rely on that lake for their drinking water or who need a healthy fishery for their livelihood. He didn't know the extent to which his actions affected the health of an entire bioregion.

Uninformed decisions put communities at risk all the time. Until the late 1960's, industries were allowed to pollute our waterways at will. Our rivers were, in many industrial cities, no more than the source of water for industrial processes as well as the sewers that carried toxic waste elsewhere.

Forty years ago, oily debris floated on the surface of the Cuyahoga River as it flowed slowly along its industrial channel, through the city of Cleveland, Ohio, on its way to meet Lake Erie. On a day in June of 1969, a spark, or a blob of molten ore, depending on who is telling the story, leaped out of a rail car carrying material across a railroad bridge from the steel plant's furnace on one side of the river to its mill on the other.

The spark fell to the river, ignited the floating debris, and the last and most famous Cuyahoga River fire leaped into flame. Although it was a relatively small fire and was extinguished in mere minutes, it was the right fire at the right time in the right place to bring the nation's attention to the terrible state of our country's rivers, our fresh water resources and our shocking disregard for the environment in general. That event helped motivate Congress to pass the Clean Water Act, and before long various federal and state agencies emerged to enforce the new environmental laws that would come. Many claim the Cuyahoga River fire sparked what would become today's environmental movement.

Within a decade, schools were bringing environmental education to the classroom, expanding the study of the natural sciences to include what was happening in the field – loss of species, air and water pollution, forest and habitat removal, the loss of wetlands and overuse of pesticides.

Unfortunately, for the vast majority of community leaders, elected officials and citizens, the environmental education curriculum did not include "Watersheds 101." Yet every day you are expected to make decisions that will affect how this natural infrastructure functions and will have implications that reach far beyond your community's or property's boundaries.

This book is meant to provide the most basic information about the workings of watersheds so that you can make the best possible decisions for yourself and your community. It will not make you a hydrologist. It will not qualify you to replace your city engineer. But it will equip you to suggest alternative ways to manage water on your property and your city's public lands, contribute to healthy streams, and make you a more effective steward of your natural resources.

We'll start with the basics – what a watershed is as a physical place, what pieces fit together to make the whole, how the watershed works as a system and how it keeps itself in balance, in nature. Then we'll introduce you to the changes that come when we add the built environment, how they throw the system out of balance and what happens to the whole when a few pieces of the system fail. Finally, we'll offer ways to bring the system back in balance, or at least keep it from going further off center while still allowing communities to have economic growth through sane development and green development practices. Everyone has a stake in clean water and healthy watersheds, and we'll show how each of us has a role to play.

Along the way we'll throw in some interesting info-bits and we'll clue you in on the lingo that the pros use, so you don't feel so much like a fish out of water. Since we work in the Cuyahoga River Watershed in the Lake Erie Basin of Ohio, the type of landforms and bioregions we describe are most common in the Great Lakes region. It's imperative that we take better care of the 80+% of our country's fresh water that's in the Great Lakes. But the basic workings of watersheds are the same the world over, and the need to conserve and protect our fresh water environments exists everywhere.

A watershed is a place.

It is an area of land in which all the water or snowmelt drains to a single stream, river or lake.

You can think of it as you would a sink or basin in a home, where everything that lands in the bowl slides into the drain. In fact, watersheds are drainage basins on a larger scale.

Aside from sheer size, the differences between your kitchen sink and a watershed have to do with their shapes and surfaces. A watershed in nature is anything but a smooth, clean and shiny porcelain bowl.

The terrain of a watershed is the result of the geology that shapes the ground into flat or hilly areas, and the action of water that erodes soil and shapes streams.

The living layer that makes up the surface is the result of time, weather, friction, gravity and biology.

So a watershed is a specific place on earth that collects the water that falls within its boundaries and directs it to a single destination.

A watershed is also a system.

It is the complex system of interactions between the land, water, plants, animals and built structures that exist in the place.

Those interactions clean the water and support the habitat that, in turn, supports life.

In the same way your house is a structure that holds water and waste pipes, gas lines, air ducts and wiring conduits, it is also the organizing system in which the gas gets to the hot water heater and the hot water gets to the shower and the dirt from your shower flows out the sewer.

So a watershed is nature’s infrastructure, designed to keep water, land and life in balance.

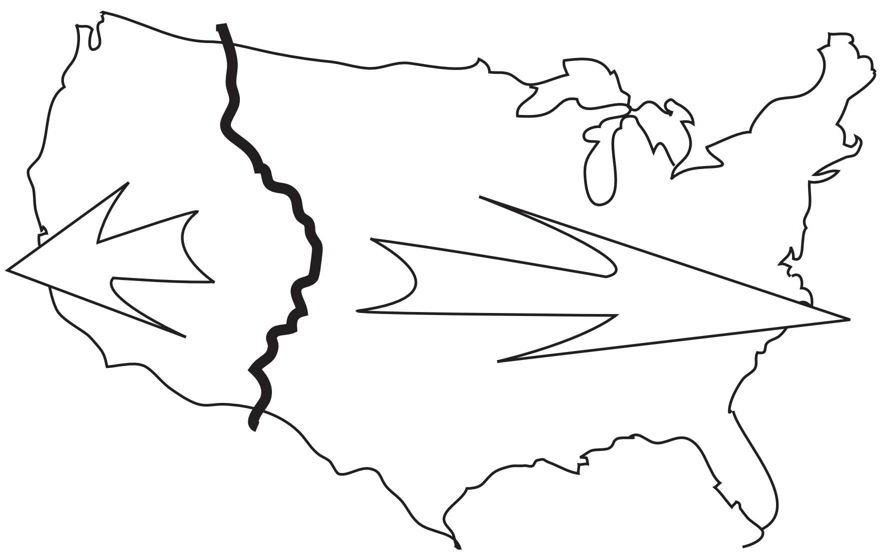
The Watershed as a Place

North American Watersheds

In North America, almost all the water that falls on the land as rain or snow ultimately flows either to the Pacific, Atlantic or Arctic Ocean. The continental U.S. comprises three primary watersheds.

The Great Divide
Running north to south, from Alaska through western Canada, along the Idaho-Montana border, then running down through Wyoming, Colorado and New Mexico, the Continental Divide, also known as the Great Divide, is the ridge and range that separates east- from westbound water.

North to the Arctic
The Northern Divide, which separates water going south to the Atlantic from water going north to the Arctic Ocean, starts near the Idaho-Montana/U.S.-Canadian border and runs east and northeast to the Labrador Sea. Except for the northern and eastern sections of North Dakota, a small piece of northern Minnesota, and the north coast of Alaska, this watershed is within Canada's borders.



West to the Pacific
Water and snow falling on the west side of the divide is bound for the Pacific Ocean. It makes its way there either directly off the coast or by draining into a larger river like the Columbia River and northwest, the Colorado River and southwest, or the Sacramento River north through California and out to the ocean.

East to the Atlantic
The vast midsection of the continental U.S. from the Rocky Mountains to the Appalachians sends its water to the Atlantic via the Gulf of Mexico, either directly or by way of the Rio Grande or Mississippi Rivers. Atlantic-bound water falling along the eastern seaboard of the United States flows directly to the ocean or is carried into a stream that joins a river and takes it to the ocean.

There are, of course, exceptions:
Some water doesn't drain to an ocean at all. For example, The Great Basin, covering the western half of Utah and almost all of Nevada, has no outlet. The mountains and valleys collect rain and snowmelt as groundwater, and most of the scarce rain evaporates quickly in the dry deserts and dried up remnants of prehistoric lakes.

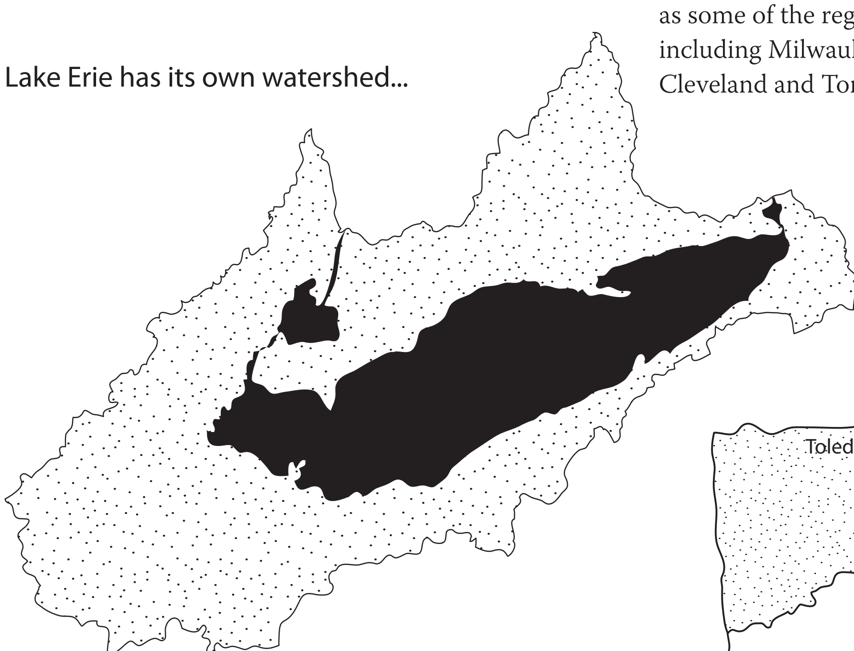
Watersheds within watersheds.

The larger a watershed is, the more likely it is to be made of smaller watersheds. At the North Coast of the continental U.S., the Great Lakes share one large watershed that starts in northern Minnesota and runs east/northeast for 750 miles along the U.S. - Canada border. Each lake also has its own drainage basin, or watershed, which is made of smaller and smaller subwatersheds.

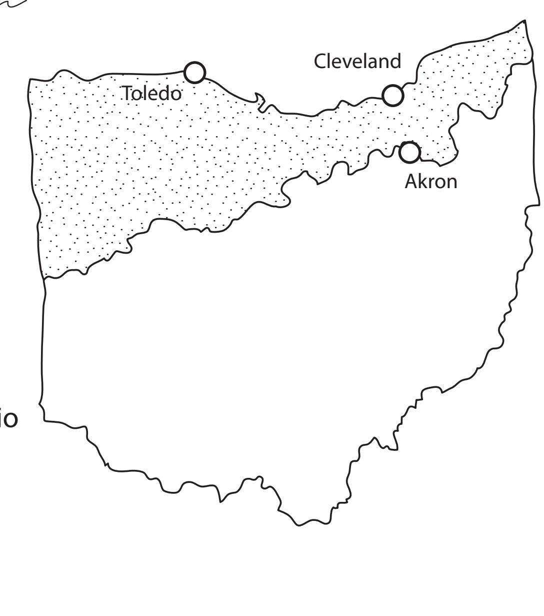
The Great Lakes system manages waters in five lakes, then flows through the St. Lawrence Seaway to Montreal and along the St. Lawrence River to the Atlantic Ocean at the Gulf of St. Lawrence. The northern edges of New York and Ohio, and the northwest tip of Pennsylvania are in the Great Lakes watershed, as well as all of Michigan, small sections of northeast Indiana and Illinois, and the shoreline regions of Wisconsin and Minnesota.

The Great Lakes basin holds 20% of the world's fresh surface water and more than 80% of the fresh surface water in the U.S. More than 30 million people live in the basin – roughly 10% of the U.S. population and 30% of Canada's. The basin holds some of the most pristine forests and cleanest water, as well as some of the region's most industrialized cities, including Milwaukee, Chicago, Gary, Detroit, Cleveland and Toronto.

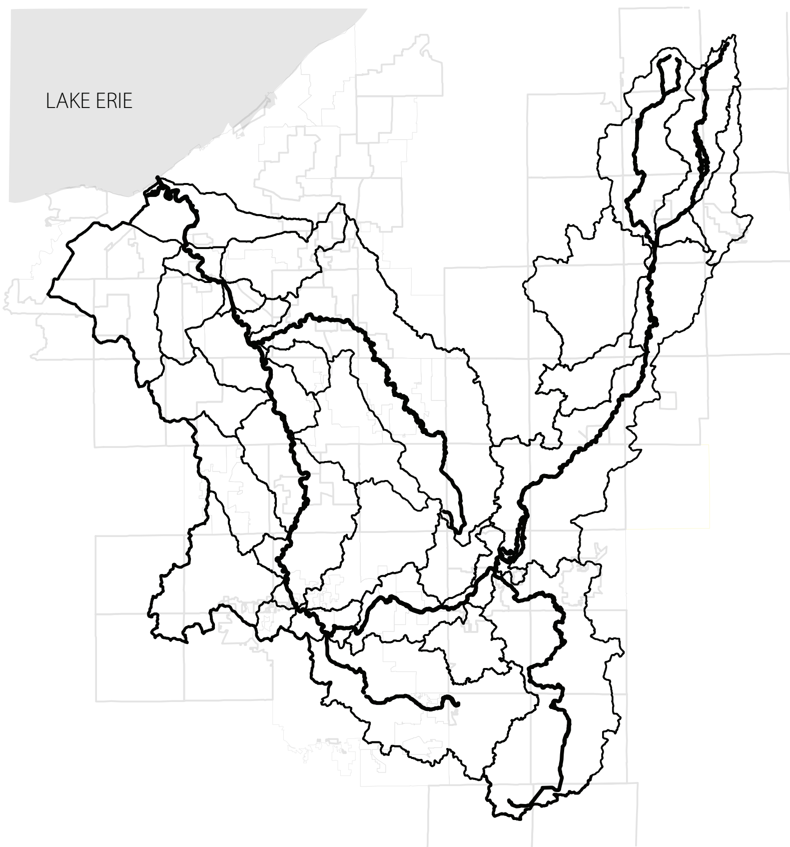
Lake Erie has its own watershed...



...that includes the northern part of Ohio



...which includes the Cuyahoga River's watershed...



...which includes its tributaries, each draining its own subwatershed.

Spread across this particular watershed are dozens of municipalities – cities, villages, townships – each with its own set of zoning maps, building codes and community characteristics.

One community might be mostly rural, farmers raising livestock or crops on great swaths of fields, or both. Their water comes from wells, their waste goes through a septic system. Next door the community might be more suburban, with homes on large turfgrass lots, their water comes from the river, their waste is treated in their local treament plant. A third community is more urbanized, having started life as a business and industrial center. Their water comes from the lake many miles away, their sewage is treated at a large regional plant. Seemingly different as night and day, all three communities share one thing. All or part of each of these municipalities is in the same watershed as its neighbors.

Nature is oblivious to politics and has no respect for lines on maps. Water doesn't care that someone once drew survey lines that separated town A from village B, it knows only gravity. Smart surveyors used the edges of watersheds, obvious by the ridges of high land as dividing lines. The same surveyor often found it expedient to use a stream or river as a divider. This last habit has often set communities against each other as much as it sets them apart from each other. Who owns the river? The water? If one has setback laws, and the other doesn't, what then?

Sharing watersheds – communities brought together by nature.

If you're thinking a lot about regionalism, think about watersheds as nature's way of bringing communities together.

Water falls where it will. The more we try to control it and direct its flow, the more expensive the effort becomes and the more and more serious unintended consequences crop up, which in turn require more attention, and the cycle goes on and on.

In the mid-twentieth century, suburbs with roads, driveways, roofs and large expanses of turf grass began to replace wetland storage areas, permeable fields and water-retaining forests.

Until then, the natural infrastructure of wetlands, deep-rooted native meadows and soil-holding forests managed precipitation as important pieces of nature's storm water management and plumbing system.

As the built infrastructure replaced the natural one, and engineered storm water management structures replaced wetlands, flood plains and meandering streams, the tendency was to "rush and flush" storm water out of the immediate area as quickly as possible.

Older, downstream, communities were built closer to a stream or river's mouth, where more water and stronger flows could run mills or provide power and serve industry and commerce, and surface water was more accessible. Farms, and the suburbs that replaced them, tended to be upstream, closer to the stream's headwaters.

As outlying rural areas become more urbanized, the areas where the two types of land use meet have become the front line of inter-municipal strife. Since water only flows one way – downstream – those communities are dealing with new flood zones where none existed when water had room to spread out and filter into the soil farther upstream.

As government regulations require municipalities, and property owners, to hold storm water onsite longer and release it into the system more slowly, storm water management gets more expensive. As paving over greenfields keeps more groundwater running over the surface, the challenge of figuring out what to do with it and where to store it becomes a real problem.

Cities, villages and townships grouped together by geology have, literally, common ground when it comes to storm water.

{ Upstream communities can no longer "wash their troubles downstream." }

Communities that share a watershed and work as partners to manage and steward its resources can benefit from the collaboration in many ways:

Balanced Growth Land Use Planning -
If communities decide what land to conserve and what land to develop based on watershed function rather than convenience, they can let the built-in infrastructure do its job and still have development.

Zoning categories that retain or increase natural water management areas (not simply big ponds) can be applied watershed-wide, so that a downstream community does not become the victim of another community's rush to develop in a way that compromises the functioning of the natural system.

Consistent Best Management Practices on Public Lands - If all communities in a watershed agree to mow higher, leave more land as meadow or prairie, stop mowing to the edge of swales and waterways, and plant riparian zones on land they own, they can save money and support the built-in systems.

Consistent Building and Housing Codes - If all communities have the same codes that allow or encourage best watershed stewardship practices on private property, such as allowing rainbarrels, rain gardens, permeable paving, limited parking lot size, and more naturalized landscaping, then benefits could be shared throughout the watershed.

Where Place and System Meet

Although every watershed is a place, and defines a space, it is also defined by the space it inhabits, and it is the material with which and on which the laws of physics operate. Gravity is the law that rules over all. Even the water cycle – liquid evaporating to rise to fill clouds to fall to earth as rain – counts on gravity to bring the rain down to earth.

It is in the shape and slope of the land and the texture of the features on its surface, the forests and wetlands, parking lots and playgrounds, where we see most clearly how the physical characteristics of a place affect the functioning of the system.

The lay of the land

The shape and texture of the land has a lot to do with how water moves on the surface. The steeper the grade the faster the water, the flatter the land the slower it flows.

In one watershed you can often find a wide variety of topographical features – rolling hills, flat fields, downcut streams – and in addition to individual areas, the whole watershed's underlying grade tips toward the outflows of its main stream.

Flat lands are usually wetlands or former wetlands, level so as to hold more water. Flood plains along streams and rivers are relatively flat, too, so that the overflow can spread thinly over the surface. Streams meandering through flat lands move slowly.

Hills can speed up surface flow and runoff into streams, and they can form pockets where small amounts of water can be held, to filter down into aquifers. The transition areas between hills and valleys, or hills and mountains, are often the places where springs bubble cleaned water to the surface from aquifers, and here begin "spring-fed" streams, ponds or lakes.

Valleys can be the result of glaciers scouring the land and melting away, or they can form through stream erosion cutting down through soft stone. Or they can be a product of both processes.

Water is an effective tool, whether it works as a shovel to move soil and sediment or as a chisel, slowly wearing away at rock walls. Over time, water can carve a ravine, which can be enlarged into a gorge, a deep, narrow valley, or a canyon cutting through stone walls.

Underlying rock formations can direct the flow and the result is a collection of unique ecosystems. The differently carved valleys and ravines offer areas that are low or high, open or forested, wet or dry, flat or steep, sandy or clay or rock. Each environment provides habitat for a different collection of flora and fauna.

The Watershed as a System

The various watershed features work together to manage inputs and outputs so as to support life in a sustainable manner, sustainability here defined as health – the ability to function over time – and renewability, the ability to renew the physical elements that support health.

The primary functions of the watershed are:

• CAPTURE

Any depression is an obvious place to capture precipitation. Ponds and wetlands are the most obvious examples of natural structures whose purpose is to capture and hold precipitation for long periods.

Plants, too, are often well-suited for this work. Large-leaved plants direct water that falls on them down along the leaf or stem to their root systems where a lot of water can be held and used to grow more plant tissue.

• FILTRATION

Undisturbed forest or field offers vast surface area to allow rain or snowmelt to soak down into the soil. Some of it will filter all the way down to aquifers for storage, some will stay near the surface and show as streams or wetlands.

Both the soils and the roots of plants are the filtering media that clean the water.

• STORAGE

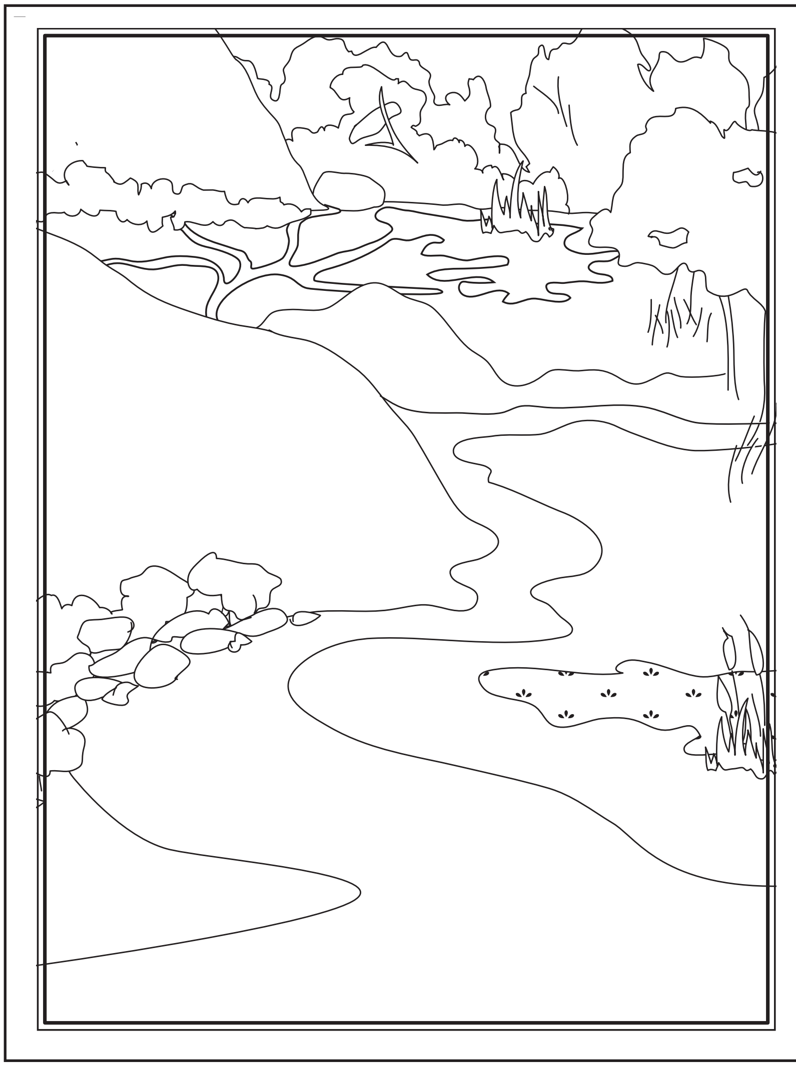
The deepest storage receptacles are underground aquifers, porous stone sponges that receive and hold water that has been filtered by many layers of soils. Closer to the surface are stone catchments, often found in forests, carved by years of water dripping from the tree canopy, that hold water temporarily.

Surface storage sites are wetlands, lakes and ponds.

• CONVEYANCE

Overall, the function of a watershed is to move water to where it is needed in order to support life. The topography that shapes the land is not just a canvas on which the watershed is drawn, it determines where the storage areas are, and where the streams run, and where the swales need to be to direct water to the stream. The smallest depression will move water either toward a storage area or toward the main stream. Eventually, whatever doesn't get stored gets transferred to ever larger streams, rivers, and the ultimate destination, a lake or ocean.

The evaporation of water off the surface, and the transpiration of it through the exhalation of plants conveys water to the air to become precipitation, falling to earth once more and fulfilling the water cycle.



Watersheds in Nature
Systems in balance

Land that is not altered to serve humans' desire for shelter, transportation or commerce will provide all of nature's plants and animals with food and shelter and clean water.

The land works as a water and soil management system with features that do the work of capturing, storing, conveying and processing water so as to keep the system in balance.

That system and the structures that comprise it – wetlands, floodplains, streams, aquifers, hills and valleys – constitute the natural infrastructure that supports life. The land, its shape, the texture and content of its soil, the plant material it holds, processes into food and feeds to the roots that hold the soil in place, are perfectly designed to maintain a balanced system.

Too much rain coming down too fast?

- Wetlands, lakes and ponds will catch a lot of it and store it for a while, as
- trees and shrubs will interrupt the force and hold water in canopy and leaf, slowly dropping it to the surface, where...
- loose, friable soil, rich in organics absorbs and holds water and
- root systems absorb water and direct it downward.
- Streams gather water that runs off the surface and over its banks, and
- collects groundwater filtering into it below the surface, and
- sends it downstream, where it collects more water and picks up some sediment from its bed or banks to slow its flow.

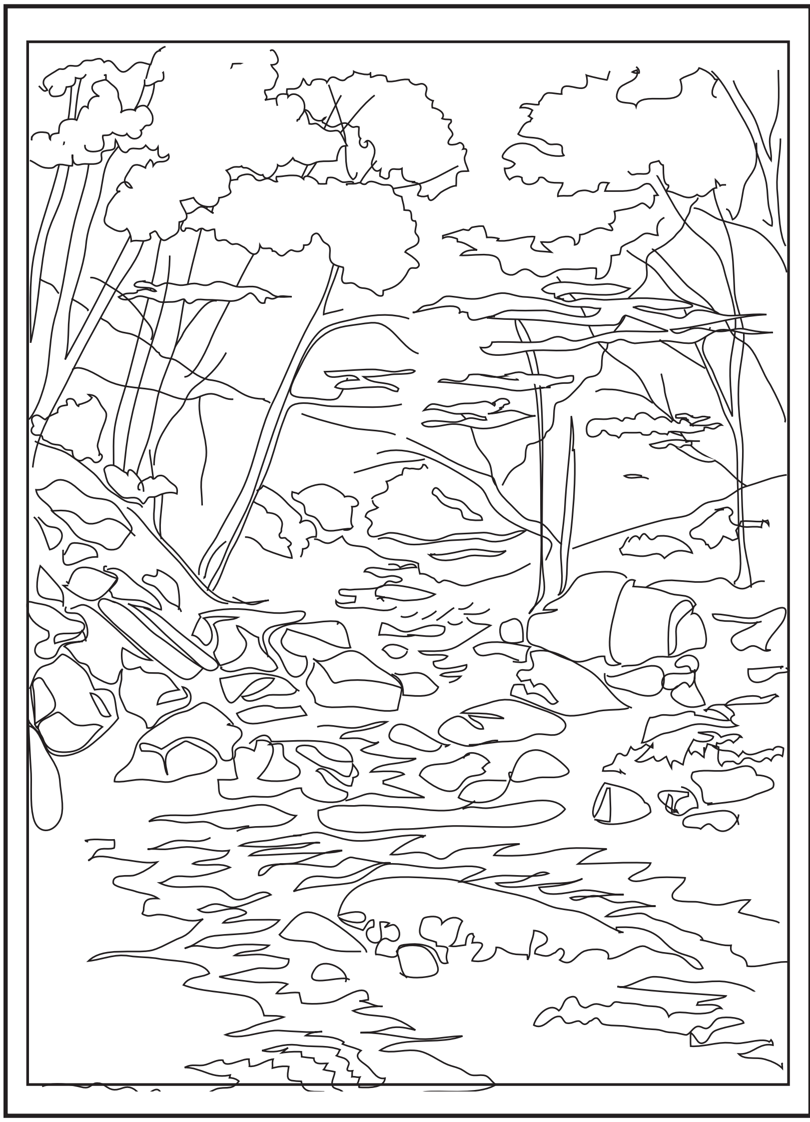
Too much for the stream to manage?

- Stormwater overflows the stream banks and spreads out over the floodplain, nature's safety valve, conveniently located adjacent to the stream, where
- vegetation slows the flow and nutrient-rich sediment settles out of the water, which
- slowly recedes back into the stream, percolates down through the soils all over the watershed, so it
- recharges aquifers deep underground that will supply springs that start new streams.

And the living things?

- The water feeds the plants that drop their leaves, which decompose and feed the tiniest creatures that feed the bugs and fish and birds, which live in the trees that house insects and store vast amounts of water and breathe out water vapor that fills the clouds that drops the rain that...

keeps the cycle going....



Streams

the watershed's management system

Streams manage the volume and energy of stormwater in a watershed, while at the same time providing food and shelter – habitat – for aquatic and terrestrial life, and making drinking water available to surface-dwellers.

Streams are dynamic systems that change their size and shape to adjust to conditions in the surrounding watershed.

They use sediment to regain equilibrium. If a greater volume of water comes into the stream as surface runoff, or if the the velocity speeds up because of a steeper grade or water coming in via a straightened channel, the stream will try to balance the increased energy by picking up sediment, which slows the flow. It will get the extra sediment from the stream bottom or by eroding its own banks.

On the other hand, if there's more sediment running off the surface than the stream has the energy to handle, extra sediment will fall out and settle on the bottom. This makes the stream shallower, so the stream can carry less water and is more likely to overflow its banks. When it overflows, some of the sediment that washes out over the flood plain will stay on land enriching the soil.

Too much sediment coming off the land, adding to the sediment the stream itself collects to manage equilibrium, can present problems for aquatic habitat and therefore aquatic life.

{ Sediment is a major problem in streams and rivers where urbanization creates too much runoff from impervious surface, builds berms with steep slopes that erode, strips ground cover too close to the banks, or where construction removes plant cover and allows soils to erode either via storm drains or directly into streams. }

The trees and plants that congregate along streambanks, creating riparian corridors on either side, do so because that's where they find a steady supply of water. In turn, the roots that absorb the water also stabilize the soil in which they grow.

Throughout the stream are rocks, boulders and stones that are in the process of being broken up and worn down by the weathering force of running water and the freeze-thaw cycle. Eventually this material will become the inorganic component of sediment and soils. The flooding function carries some of that mineral content to the land. While in the stream, these natural structures can in some places moderate flow and in other places create riffles that activate and aerate the water. They also give shelter to fish and aquatic creatures and help stabilize plant roots.

Streams
about size

Stream Order describes the relative size, capacity, flow and speed, as well as the complexity and diversity, of streams, from the smallest, simplest, to the largest and most complex.

Headwater Streams are the swales, creeks and streams where surface water first gathers. They are considered the "source" of a stream or river. Some are fed by groundwater just under the surface, others are fed by spring water rising to the surface from underground aquifers – natural storage areas in deep layers of porous rock.

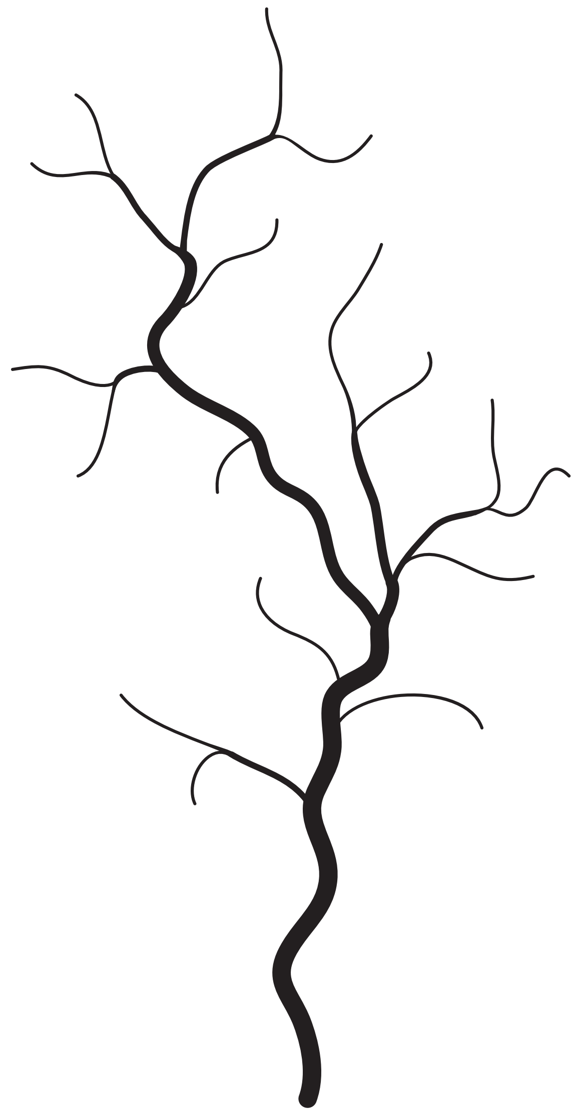
The smallest of these, called **Primary Headwater Streams**, collect water from, or drain, a small area of land. In many places they are defined as draining an area less than one square mile.

Primary headwater streams are nurseries for waterborne life, with slow-moving water supporting little aquatic life, in simple forms, with little competition for resources. They are often in forests, where little photosynthesis takes place. Bacteria and insects process nutrients from the land into usable forms for downstream creatures.

Larger headwater streams use the nutrients coming from the primary streams. They spread the forest canopy open so that plants can use sunlight to create energy and food for more and larger aquatic life.

The larger the stream, the deeper and faster the water, with more energy, moving more food and oxygen around, and hosting more kinds of aquatic life on more levels of size and complexity. Here there are more, and stronger, organisms competing for resources.

Headwater streams are important because they capture and manage most of the water in the stream system. The more small headwater streams there are, the more room there is to manage water before it reaches larger streams.



{ In urban and suburban areas, most of the small feeder streams are invisible to us because they run in pipes underground. }

Approximately 80% of Ohio's streams are headwater streams. In more rural areas, and forested lands, we may not notice the number of small streams running over the land. In more urbanized areas we don't see them because most of the small streams have been channeled into culverts that run under roads and pipes that run under buildings.

Getting Streams and Giving Streams

A **Gaining Stream** (*effluent*) gets water from either:

- Above: as precipitation, aka rain, falling onto the stream or running off the surface and over the edge of the bank, or
- Below: as groundwater, aka baseflow, where precipitation has soaked into the surface elsewhere and is stored belowground, then seeps through the bed and bank into the stream.

The gaining stream's role is to collect extra ground-water and carry it downstream to discharge it, in order to balance the watershed's water inventory.

A **Losing Stream** (*influent*) gets water only from rain, or snowmelt runoff, and collects it temporarily so it can filter down through the streambed to recharge the groundwater supply.

Depending on the water table and conditions, a stream could switch between gaining and losing.

Perennial, Intermittent and Ephemeral Streams

A **Perennial** stream typically flows **always**, unless the water table drops severely through drought.

An **Intermittent** stream flows **sometimes**, usually with seasonal changes in precipitation, like spring, when the water table is high.

An **Ephemeral** stream flows **rarely**, only after a rain, or in spring when snowmelt runs over the surface.

Gaining streams are perennial.
Losing streams are intermittent or ephemeral. Usually.

What's the difference between a river, stream, brook, run, and creek?
Size, mostly. Geologists use "stream" to refer to a body of running water that moves downslope, under force of gravity, on the surface of the planet. So rivers, creeks, brooks and runs are all streams. In general, a river is bigger than a stream, which is bigger than a creek, brook, or run .

Streams
about shape

Water and land cooperate to shape a stream so that it moves its water through the landscape at the right speed and in the right volume to keep the system in balance.

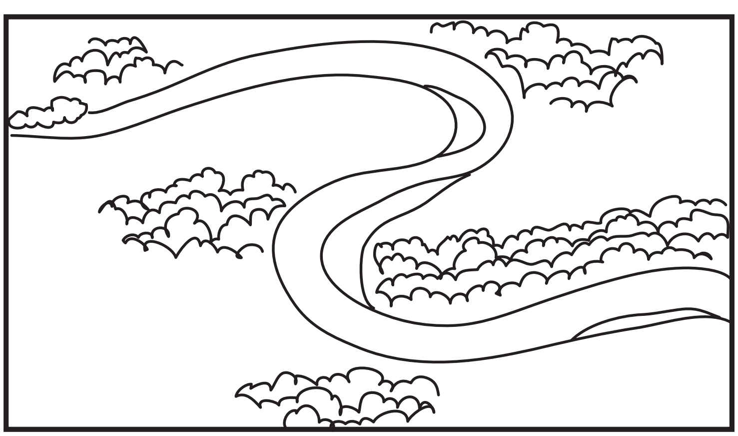
A stream's primary goal is to discharge its water into the receiving stream or body of water, whether that's a surface river or lake or an underground aquifer, at a constant rate. This is a stream's definition of balance as far as flow is concerned.

Gravity is the primary force that rules how water flows and where water goes in a watershed. Young, straight streams accommodate fast flow by dredging a V-shaped channel, or downcutting.

Once water is in the stream, the steepness or grade of the terrain, the width of the channel and its depth, the surrounding land area, and the load of sediment the water is carrying all affect how fast the water flows and what shape the stream adopts to manage it. Steep mountain streams are straighter than those that flow over flat lands. The first has no time nor room to maneuver, the second has plenty of flood plain over which to spread out.

In order to keep the system balanced, a stream will start to meander, eroding soil from one bank and depositing it at another. The removal of material on the outer curve of a stream will increase the stream's meander, making the curve bigger, which in turn makes the stream longer. A longer stream can hold more water, and the water in a curvy stream will take longer to reach its destination. A stream slows itself down by making itself larger, in length if not in width.

Meandering streams hold more water, and the increased bank areas give more access to flood plains, so the more room there is to meander upstream, the less flooding there is downstream.



Curves are good

Two streams that cover the same distance as the crow flies are not necessarily equal.

The one that curves is longer than the one that runs in a straight line.

The longer the stream, the more water, habitat and life it can hold.

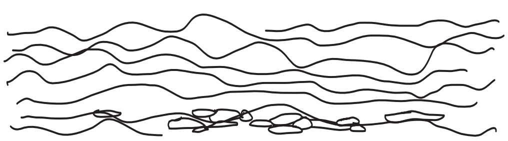
Streams also change depth in order to change capacity and the flow of water.

When you look at the surface of a stream you can often see the bottom, and even when you can't you can guess at the depth and shape of the stream's "floor" by how the water on the surface behaves. The underwater shape and contents of a stream fall into three main categories:

Riffles...

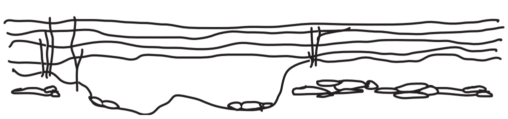
- shallow, rocky areas
- where the surface of the water jumps and splashes after rains or flows more slowly in dry weather
- where surface action dissipates energy as it adds oxygen to the stream
- home to small organisms at risk if sediment clogs or covers bed

Runs...



- deeper overall
- fast, free flowing areas
- move energy, nutrients and sediment downstream
- home to many different sizes and types of aquatic life, in more abundant and varied habitat

Pools...



- deepest areas, often where stream has undermined root areas along bank
- slow flow
- little energy, nutrients gather and drop
- create inviting fish habitat, especially for largest species

Floodplains

storing overflow, calming the waters

Floodplains are important pieces of the stream system, functioning as holding areas for seasonal or emergency overflows (or, as we call them "out of bank events." Just because they aren't always filled with water, that doesn't mean you can build there. Many have done so, to the detriment of the stream and their possessions.

Floodplains are the low-lying flat lands that border steams and rivers. When a stream reaches its capacity and overflows its banks after a heavy rain or a sudden spring snowmelt, the floodplain provides an area where excess flow can spread out, be stored temporarily, and then be slowly conveyed back into the stream system either through infiltration or surface runoff.

In their natural state, floodplains reduce flow velocities and peak flow rates by passing the energetic water through dense vegetation. Floodplains also play an important role in reducing sedimentation as they capture sediment that arrives with the overflow. They filter runoff as it gets absorbed back into groundwater when the water level subsides.

Because they are transition zones between aquatic and terrestrial ecosystems, they provide varied habitat for all kinds of flora and fauna, much as wetlands. Unlike wetlands, their soils are the same as the surrounding lands, suited for supporting aerobic soil life and forest, prairie or brush vegetation.

The term "100-Year Flood" refers to an elevation – a water level – that has a 1% chance of being reached or exceeded in any given year.

This is how FEMA, the Federal Emergency Management Agency that draws the maps of floodplains for insurance purposes, defines it.

It doesn't refer to a flood that's expected to happen only once in a hundred years.

As headwaters get channelized, built in and piped over, as wetlands are filled and built over, and more impervious surfaces are laid down upstream, flooding is becoming more common as downstream segments are overloaded. That is why 100-year floods are happening more frequently than you'd expect.

The New Nile: Unintended Consequences

Before the Aswan High Dam was built, and going back, well, forever, the Nile River would overflow its banks every year, bringing millions of tons of nutrient-rich sediment out of the river and onto the floodplain, creating the fertile agricultural lands that allowed the Egyptian civilization to flourish. Now, farmers have to use millions of tons of artificial fertilizer to produce the same amount of crops and the soils of Egypt are barely meeting the needs of farmers.

Floodplains

enriching soils, providing habitat, recycling nutrients

In addition to being places to hold excess water, floodplains serve as rich, diverse habitats for plants and animals, some of which can only thrive in the calm, relatively shallow waters left over from spring floods. Some larval fish rely on the shelter from predators and the slow flow back into the stream that these backwaters provide.

Floodplains are also the places where recharging of soils takes place, with nutrients that have concentrated in the stream and sediments that have been carried there now being transported by flood waters out to fertilize the land.

As some of the stream's nutrients are exported to the land in this way, they are filtered out and left behind to naturally enrich the soils, and the water returning to groundwater supplies is cleaner. The enriched soil supports wide varieties of wildlife, aquatic, terrestrial and avian. The habitat is one of the most dense and complete food chain webs of any environment.

The give and take between stream and floodplain cannot occur when levees or other engineered barriers stand between. In those cases all the nutrients and pollutants in the stream stay in the stream and accumulate all along its course. In the extreme event of an overpowering, levee-breaching flood, there is no wide-ranging return path for the floodwaters. If you separate the two pieces of the system, it's no longer a system.

Wetlands

nature's storage sponges

Wetlands dissipate the energy of stormwater, store and slowly release water into streams and groundwater, filtering out impurities. They provide critical habitat for wildlife. They are our first defense against downstream flooding and erosion.

Wetlands are areas inundated by water long enough or often enough to support vegetation adapted for life in anaerobic or hydric soils. That's the legal definition, and helps in identifying wetlands because only a small percentage of soils are hydric and only a limited number of plants can live there.

Most soils are aerobic, meaning there is oxygen present and used by plant roots and organisms that live in the soil. Prolonged saturation reduces the amount of oxygen and oxygen pathways, so the upper layers of soil become anaerobic, "without oxygen," and different plants and organisms inhabit the area.

Only areas that meet the soil criteria are labeled wetlands. Your property may have areas that are inundated regularly, but if they drain and retain the same plant matter and soil characteristics as the surrounding areas, that doesn't make the area a wetland (though it's an important temporary storage area anyway, and should be left alone or converted to a rain garden.)

Wetlands can be forested with tall oaks and maple trees or dominated by smaller understory dogwoods and scrub. They can look like great swathes of grass and wildflowers, or mossy peat, or wide open marshes.

Wetlands can be associated with streams or floodplains or coastlines of larger water bodies, or they can be isolated.

Wetlands

quality matters

Wetlands are described and rated by their quality, that is their health and their ability to carry out the functions of a wetland.

In Ohio, a Rapid Assessment Method (ORAM)* has been developed to describe these categories, and in each case the category includes forested wetlands with trees greater than 20 feet tall and unforested wetlands without trees taller than 20 feet. From best to worst, they are:

CATEGORY 3 wetlands include superior habitat, or superior hydrological or recreational functions, and are typified by high levels of diversity, a high proportion of native species, and/or high functional values. Category 3 wetlands include wetlands which contain or provide habitat for threatened or endangered species, are high quality mature forested wetlands, vernal pools, bogs, fens, or which are scarce regionally and/or statewide.

A wetland may be a Category 3 wetland because it exhibits *one or all* of the above characteristics. For example, a forested wetland located in the flood plain of a river may exhibit "superior" hydrologic functions (e.g. flood retention, nutrient removal), but not contain mature trees or high levels of plant species diversity.

CATEGORY 2 wetlands support moderate wildlife habitat, or hydrological or recreational functions, and are "...dominated by native species but generally without the presence of, or habitat for, rare, threatened or endangered species; and wetlands which are degraded but have a reasonable potential for reestablishing lost wetland functions."

Category 2 wetlands constitute the broad middle category of "good" quality wetlands, some of which hold the potential for restoration.

CATEGORY1 wetlands support minimal wildlife habitat, and minimal hydrological and recreational functions, and "...do not provide critical habitat for threatened or endangered species or contain rare, threatened or endangered species."

Category 1 wetlands are often hydrologically isolated, and have some or all of the following characteristics: low species diversity, no significant habitat or wildlife use, limited potential to achieve beneficial wetland functions, and/or a predominance of non-native species. They are often areas that have been disturbed by development or excavation or otherwise have been so degraded that there is little or no hope of restoring them to function.

These categorical descriptions exist primarily to determine whether or not an area qualifies for a given level of mitigation – replacement or improvement of one wetland when another wetland is destroyed or damaged in the course of development.

* Ohio Administrative Code Rule 3745

Marshes, Bogs, Fens - Wetlands all

A Marsh is...

- also known as a morass
- a wetland that is shallow and almost always full of water
- populated by abundant and diverse types of grasses, sedges, reeds, rushes, cattails, lily pads and low shrubs, because of its neutral pH and nutrient-rich soils
- sometimes adjacent to an estuary, and its waters can be fresh or saltwater.
- fed by surface water or groundwater, springs or rain
- an important habitat for a great diversity of birds, small mammals, waterfowl and amphibians
- what most people think of when they picture a wetland. The Florida Everglades is a really big marsh.

A Vernal Pool is...

- a type of marsh that is only inundated parts of the year,
- the breeding ground of amphibians, and therefore critical in the mainenance of the food chain
- sometimes as small as a pool, and sometimes as large as a lake

A Bog is...

- also known as peatland, moor (highlands,) heath (lowlands)
- a wetland with acidic water that comes from rainfall rather than from groundwater or runoff
- an anaerobic environment, where plant matter only partially decays, leaving mats of moss at the bottom and sometimes rafts of peat floating on top. Eventually, peat and sphagnum fill the bog and it becomes a peat meadow.
- where peatmoss comes from

A Fen is...

- also known as peatland, moor (highlands,) heath (lowlands)
- less acidic than a bog, so it has higher nutrient levels and holds a wider variety of plants, primarily grasses, sedges and wildflowers
- fed mostly by groundwater flow and runoff
- sometimes a precursor to a bog, if enough peat builds up and the fen becomes more acidic

A Swamp is a Wooded Wetland

A swamp is a wetland with woody plants. Those with big trees are considered "forested" and those with smaller shrubs are...shrub swamps. In the north, they are called wetlands more often than swamps, probably due to the bad image swamps have gotten in the popular media. That scary image has contributed to major destruction of some of the country's most important wetlands.

A Forested Wetland is...

- usually associated with a river, as a floodplain that has been flooded long enough to support populations of water-loving trees
- shallow and often standing water, the specific habitat for many freshwater invertebrates like crawfish, shrimp and clams
- rich in dense, nutrient-laden organic material that supports diverse flora and fauna
- a refuge for many water-based creatures, especially when it may be the only shallow water in the area, or the only area able to retain water in dry periods
- what you think of when you picture the dark, scary swamps of the south central U.S.

A Shrub Wetland is...

- dominated by smaller shrubby vegetation like dogwood, willow and, in the south, mangrove, which covers vast parts of the gulf coast of Florida
- often full of dark water dyed by the tannin in the shrub roots
- often found next to forested swamps
- a rich habitat for many animals that are found only in this environment

Soil as structure
the medium that determines how the water moves

The texture and permeability of the soil on any given piece of land is of paramount importance in determining whether precipitation will percolate down through the ground or be absorbed and held, or let run off the surface unfiltered. That, in turn, determines the amount and speed of surface runoff...the less the better.

Permeable Soils...

- allow water to drain through easily to recharge underground aquifers or run below the surface through filtering organic material before joining a stream or lake.
- can hold back significant volumes of rainwater and filter out great amounts of pollutants.
- are also the soils that hold aerobic soil life – organisms and micro-organisms that provide organic nutrients to support plant growth, which in turn provides roots to hold such soils in place.
- are highly erodible and easily compacted, so they are the first victims of urbanization and development.

Hydric Soils...

- are the other important type of soils, structured to work in nature to provide support to plants adapted to saturated, anaerobic soils, soil life and chemistry.
- hold large volumes of water on the surface and slowly allow it to filter through.
- provide habitat to large numbers and varieties of plants, and therefore are the basis for habitat for wildlife needing open surface water.

...and defines what plants can provide which habitat for whose life.

Certain plants and soil life can only thrive in aerobic soils, while others are suited to anaerobic soils. The food chain that rises from each circumstance is designed to feed a different set of organisms, aquatic life, small mammals and larger life forms.

It is especially imperative to conserve hydric soils, as they are the basis for wetlands, the most important features for habitat, filtration and storage. It is also important to keep permeable soils friable and prevent the compaction that renders them impervious.

Soil as system

storehouse, sediment, processor, habitat

It takes a hundred years for nature, by itself, to build one inch of topsoil. It takes less than an hour for one big rain to erode away that inch, and ten minutes for a backhoe to strip away hundreds of years of earth's work.

Topsoil, where most soil life is, consists of organic and inorganic materials and water. The organics come from decomposed plant matter, and the inorganics from crushed and worn down rocks.

Storage

Soil holds water. It also stores seeds and the nutrients to support their growth. It binds minerals and allows nutrients to be taken up slowly by plant roots.

Soils moderate basic cycles and balance them. Soils hold more carbon than plants and much more nitrogen. Remember, when a plant dies its tissues are decomposed and turned into raw materials for the next generation of plants.

Processing

Tiny bacteria and fungi, larger earthworms and beetles and still larger moles and rodents digest and decompose leaf litter and spent stems, flowers and roots, breaking organic matter into soil. This decomposition of dead matter and wastes destroys some potentially harmful viruses or bacteria.

The chemicals produced through decomposition are taken up by plants as nutrients

Water Management

Soil on the land, in addition to holding water, manages the transport of water from the surface to deep aquifers and shallow groundwater supplies.

Soil in streambanks moves water from the stream to roots of the riparian plants and from the floodplain back into the stream.

Soil in the stream – sediment – is used by the stream to reshape its course, by picking it up in one place and depositing it in another, and to moderate its flow. The stream will pick up sediment to slow its flow, and drop it to speed itself up and make its bed shallower.

Life in a Watershed - Flora

The plants in a watershed are the food and shelter for the animals that live there and migrate through the area.

Woody plants and ground covers also serve a structural function as their roots stabilize soils and and act as conduits for surface water infiltration, actively drawing water down through the surface and passively offering openings for water to flow through.

At points in a plant's lifecycle it also provides nutrients to itself, to surrounding plants and to microinvertebrates and bacteria, as it contributes dead leaves and plant material to the soil. Fungi are also partners in the recycling of nutrients through the plant kingdom.

Forest

Most areas in the Great Lakes region and the temperate Americas are native forests, and are constantly trying to return to forest, despite our attempts to replace them with farms or shopping centers, factories or homes.

A healthy forest is one of the primary indicators of – and ideal environments for – a healthy stream. The quantity, diversity and placement of vegetation correlates directly with the level of stream vitality. As tree canopy is reduced anywhere in the watershed, stream function, water quality and aquatic life suffer as well.

Experience shows that the rich and diverse environment of a multi-storied forest provides all the elements necessary for stream health. The complete web of life and food chain can be present in a small woodland with a stream running through it. Many wetlands are forested wetlands.

Forest Cover...

- interrupts rainfall and slows the force with which it hits the ground, reducing erosion, and in winter it holds snow on its branches, acting as temporary storage that can melt slowly and be absorbed into surfaces;
- tall trees grow large root systems that stabilize soils over wide areas while understory trees and shrubs hold surface soils in place, especially during floods, and ground cover shades the roots of other plants to conserve moisture
- provides nesting habitat for birds and small mammals, and an ample supply of seed and fruit for herbivores, insects and prey for carnivores and insectivores
- shades and cools the soil and understory vegetation
- drops leaves that decompose into nutrients for use by all kinds of aquatic and terrestrial life

Life in a Watershed - Flora

Field and Meadow

The sun-loving grasses and incredibly diverse collections of wildflowers that inhabit these wide-open, tree-free areas provide habitat to wide varieties of wildlife. They are also very important for holding stormwater and allowing it to dissipate, and for filtering groundwater.

A prairie, which was seen more in the flatlands of the U.S. midwest and west, is a product of fire and the seeds of its grasses and sedges need fire in order to continue their cycles. A meadow or field is wetter, often holding wetlands and more wildflowers and forbs, flowering woody plants.

Many of today's meadows started as prairies, which were converted to farms and then grew as meadows on the way to becoming forests. Meadows are "placeholders" on the way to growing a forest.

Riparian Zones

Natural watershed infrastructure includes a buffer zone of healthy vegetation right alongside a stream. It protects the streambank from erosion, and its roots stabilize soils on what can be steep slopes.

This is the streamside edge of the floodplain as well, and the lower growing shrubs and groundcover are especially effective at dissipating the floodwater's energy both as it swells out over the surrounding land and as it retreats back into the stream channel.

Forests along stream edges shade streams, and for cold water habitat that function is critical to maintaining a healthy fish population. They also provide the last buffer to slow surface runoff, and beside the filtering function they can moderate the high temperatures in runoff from paved surfaces.

The more, and more densely packed the vegetation in a riparian zone, the more effective it is as habitat for diverse animal species and as a barrier to incursion by humans.

Life in a Watershed - Fauna

A simple way to determine the health of a watershed and its streams is to observe the quantity, diversity and health of its living creatures in water, land and air.

Healthy fish populations with a wide variety of species and individuals of different ages indicate that there is ample food and that conditions are good for reproduction.

If any of the links in the food chain are missing, unhealthy or over-populated, you will almost always see an imbalance in the health of populations and food supplies that connect to that link.

Aquatic Life

- requires either a warm water, cool water or cold water habitat. A warm water species such as catfish won't thrive in a cold water stream, and cold water species such as trout won't thrive in the warm water habitat.
- moves from place to place throughout the stream as the stream itself changes.
- includes the smallest bacteria and tiniest single-celled plants and fills every niche up to the largest fish.
- supports amphibian populations, as insects and odonates – dragon- and damselflies – breed in and around water, tadpoles grow in water and salamanders spend at least part of their lives in water.
- serves as habitat for turtles, reptiles, some of which live in water.
- supports terrestrial and avian food chains as mammals, birds and waterfowl feed on fish and insects.

Terrestrial Life

- includes the animals that live on the land, many of which rely on streams, wetlands, ponds, springs and pockets of water to survive – mammals, reptiles, rodents, insects, vertebrates and invertebrates, and especially those that live in the soil.
- tends to gather around water sources for access to water itself, whether its particular food source is aquatic or terrestrial.

Avian Life

- includes the birds that inhabit an area year-round as well as those that migrate through an area as seasons change.

The aquatic food chain initiates the cycle of life for many land animals and bird species.

It starts small, at the bottom, in the primary headwater streams.

Just about all carnivores that can catch fish eat fish, starting with ducks munching on juvenile fish from the stream's surface, otters and raccoons nabbing bigger fish, and birds like osprey who go swimming for their prey, or bald eagles who skim the surface.

Crayfish, the stream's scavengers, prefer their meals dead, while snails clean up algae, and mollusks filter the tiny creatures from the water.

Fish eat just about anything they can get their fins on, starting with phytoplankton and zooplankton, moving up to flies (real and imitation) and their eggs and larvae and beetles.

Tiny animals - zooplankton - get nutrients from phytoplankton, decomposed leaves and animals, feed insect larvae, juvenile fish

Small multi-celled plants - algae - feed insects, crayfish, ducks, other animals

Small, single-celled plants - phytoplankton, food for insects and zooplankton

Bacteria and microbes – decomposers – make nutrients available to plants.

Plant matter and dead animals are the base of the aquatic food system.

Cycles of Life in a Natural Watershed

The seasonal cycles of a watershed and its native flora and fauna describe its web of life. The birth, growth, death, recycling and regeneration of plant and animal life provide materials and nutrients to build soil, grow plants and renew the natural infrastructure.

Spring

The wet season. Snow melts. Some infiltrates the soil, recharging aquifers and seeping into streams. Some gets absorbed into roots and tissues as plants come out of dormancy. Some runs overland into streams. Some evaporates and falls as rain, completing the water cycle.

The abundance of rain and runoff combined with saturated soils overburdens streams, creating flooding. Floodwaters rise and cover floodplains, bringing nutrient-rich sediment back onto the land to fertilize soils. Soils have new supply of organic matter decomposing after freeze-thaw cycle breaks down tissues. Friable new topsoil layers hold more water, but are more susceptible to erosion as floods recede and spring rains continue.

Fish that had spent the winter in deeper, warmer lake waters return to the stream to spawn. Eggs, larvae and hatching insects feed the web.

Summer

Plants grow, pulling water and nutrients from soils. Forest canopy spreads over streams to moderate water temperatures for cool water habitat, and over soil to keep moisture from evaporating.

Food is abundant. Local plants' bloom schedules are often timed to provide nectar for migrating birds and insects who spend part of the year elsewhere. As summer wanes, seed production increases to supply protein and oils for winter storage of nutrients for birds and mammals.

Warmer air and more sun increases evapo-transpiration. Soils begin to dry out.

Autumn

Temperatures moderate, trees and plants reduce photosynthesis, conserve water in woody tissues, shed leaves. Bacteria begin decomposition. Evapotranspiration decreases.

Some fish migrate to lakes for winter, some insects and birds head south. Resident birds and mammals store nuts and seeds, dispersing throughout habitat.

Winter

Deciduous plants are dormant. Evergreens interrupt and store winter rains. Once the ground freezes, there is no more absorption or filtration of surface water. Streams get fresh supplies from groundwater or springs, so water is cleaner for fish and insects that move to deep pools.

Biodiversity - nature's insurance policy

Variety is not only the spice of life, it is the way nature insures continuity of species and adaptibility in the face of potential losses due to disease or disaster.

Biodiversity refers to the number of different living elements in an area. There are different levels of biodiversity, having to do with the numbers of different classes, or genera, or species, or the number of individual genotypes within a species.

Species Diversity...

...describes the variety of different species that live in a watershed.

The greater the variety of different plants and animals in a given area, the higher the chances that every niche in life's web will be filled and the food chain will remain intact.

For example, a healthy ecosystem will have at least a few different types of decomposing bacteria AND fungi, AND food microorganisms AND animals AND plants.

A monoculture of, for example, all maple trees, is not a healthy forest, it's a tree farm. And if a disease kills all the maples, there are no other trees to provide the services of the lost ones.

Genetic Diversity...

...is about a variety of unique individuals in a watershed.

Again, the greater the variety the better. For example, we are mammals, in the animal kingdom, of the genus homo and the species H. sapiens, and your genotype is basically the DNA that separates your family from mine. There need to be different families in an area so that DNA can get shared and, well, diversified.

Habitat Diversity...

...is what allows the other kinds of diversity to exist.

A healthy watershed has a variety of habitats, some on wet land, some on dry land, some in the forest floor, some up in the tall canopy, some in the stream, some in a meadow, some under rocks.

Bigger is Better

In terms of habitat, nature likes to keep things simple, by keeping large areas of habitats, rather than mixing them up. One big hunk of forest is better than a lot of little separate ones. Riparian habitats, for example, ideally are continuous corridors alongside a given stream. That allows large populations of plants and animals, and enough room to accommodate diverse species without too much competition for resources.

What makes a watershed work

elements of healthy watersheds

A watershed doesn't just hold a variety of ecosystems, it *IS* an ecosystem itself, a collaboration of soils and water, plants and animals, working together, sharing resources, with pieces moving around to manage the whole system and keep it in balance. Some principles stand out as keys to success in nature's balancing act.

Respect for the Carrying Capacity of the Infrastructure

Nature has her systems in balance, and she is constantly adjusting her materials – soil, rocks, plants, animals – to keep things that way, based on the natural infrastructure that was laid down when the geology of a place was last put in place.

A watershed manages energy, and needs room to maneuver in order to do so. Whether it's the energy of rushing storm water or the energy of the sun turning water and nutrients into plants, the more nature is constrained the more the system falls out of balance.

Respect for the Carrying Capacity of Wildlife Habitat

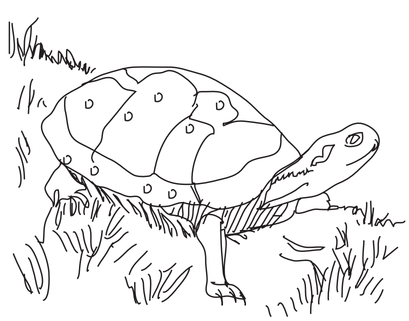
Nature regulates populations if allowed to do so. More animals require more food and produce more waste, so nature must balance, either by controlling animal populations or creating more food plants and plants that can support larger populations (and process more manure.)

That means either maintaining predator populations to manage prey populations, or physically expanding the area of appropriate habitat. That's one good reason why an area of land left alone will quickly revert to forest, where the widest variety of biota can live. Think "white-tailed deer."

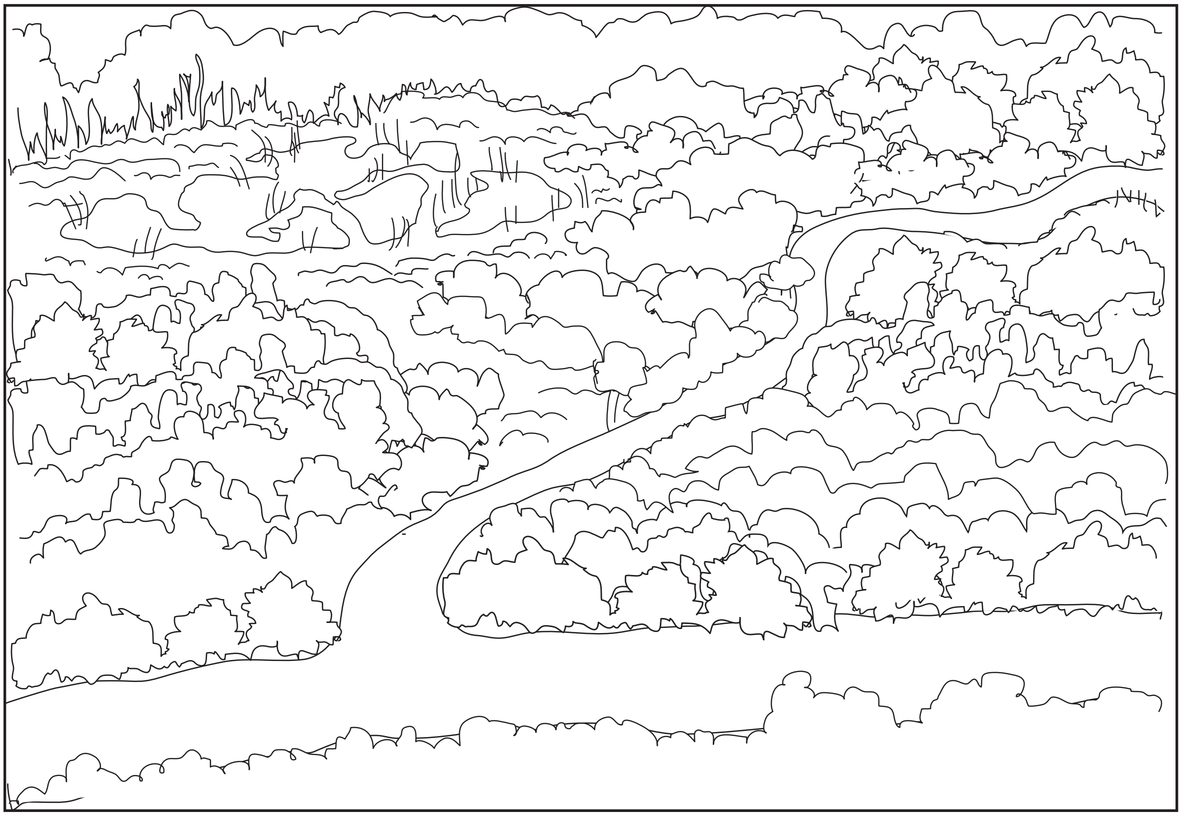
Respect for the Carrying Capacity of the Chemical Processes

Nature uses watersheds to deliver clean water to lakes, and eventually to oceans. The wetlands and soils and roots filter and clean the water before it gets to the stream that conveys it. Surface runoff into a stream in a natural watershed is minimal, and it only carries organic nutrients inherent in the plant material that, decomposing, returns its nitrogen, phosphorous, potassium and minerals to the system.

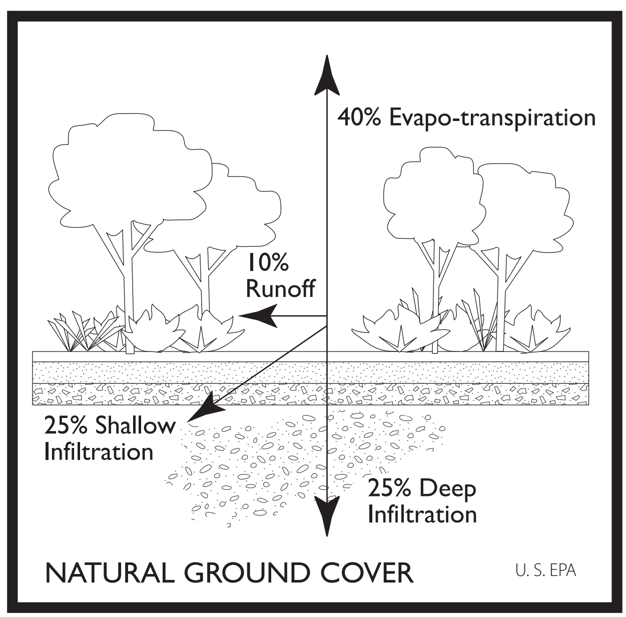
The stream bed and banks and vegetation do a great job of processing those nutrients. The system is not designed effectively to process the vast amounts or high concentrations of additional chemicals and nutrients that come as runoff in urbanized areas or as livestock manure or septic system waste in rural areas.

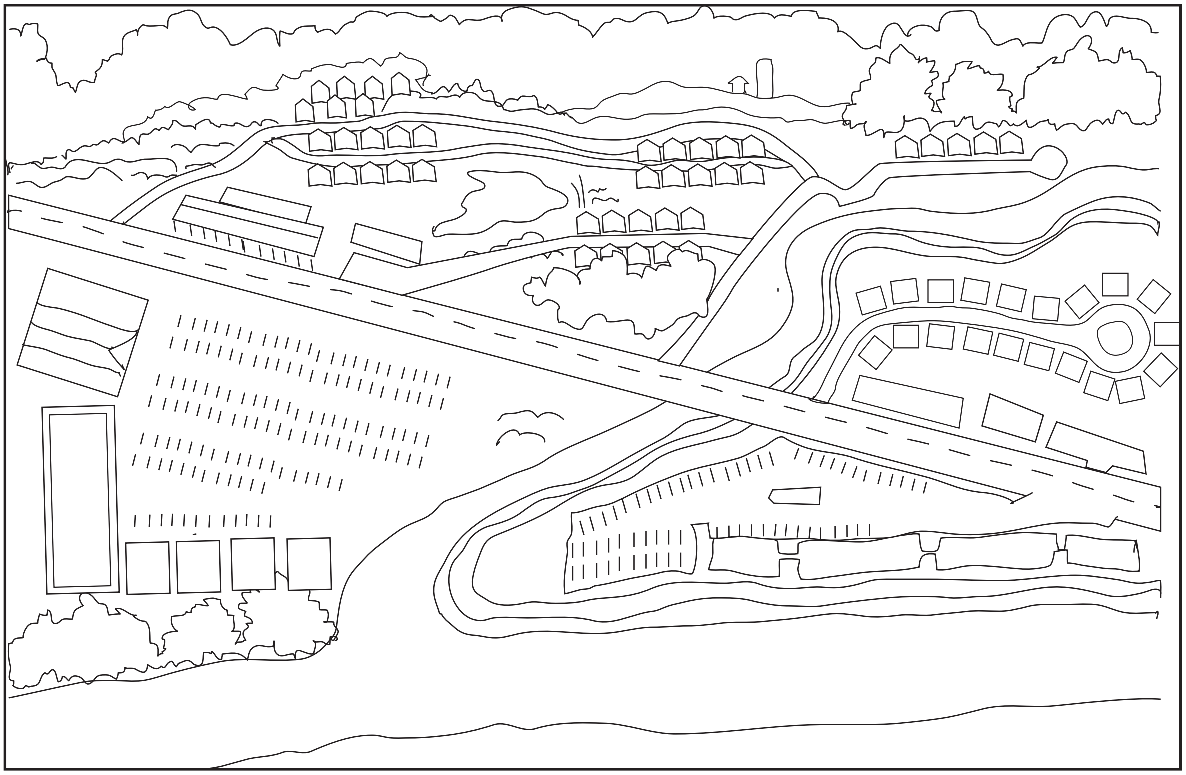


Land Use for Nature



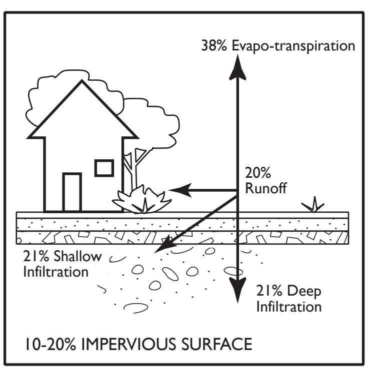
Soft, Pervious Vegetated Surfaces intercept rainfall, interrupt and slow surface runoff, stabilize and retain soil, filter pollutants out of stormwater and allow infiltration to recharge ground water for aquifers, clean the air, provide habitat and support life.

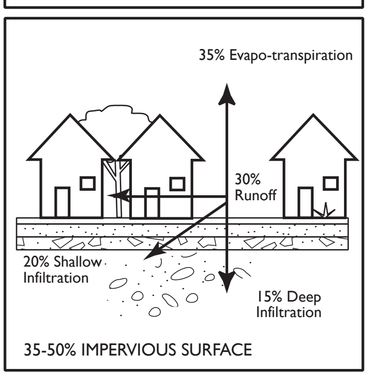


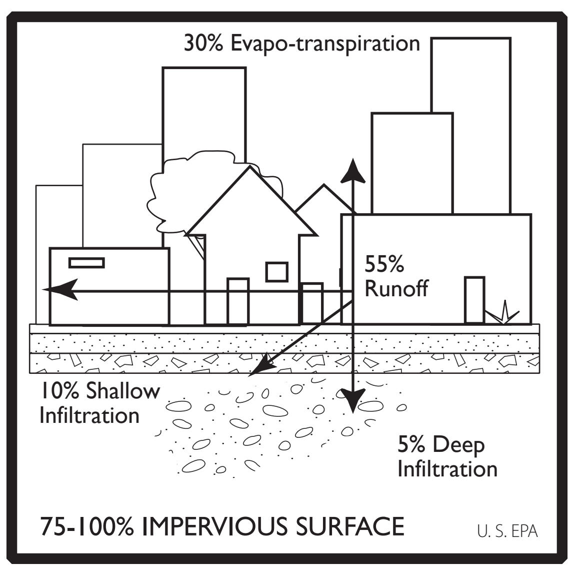


Impervious Surfaces

cause most problems with flow imbalance and contribute most to non-point-source pollution.



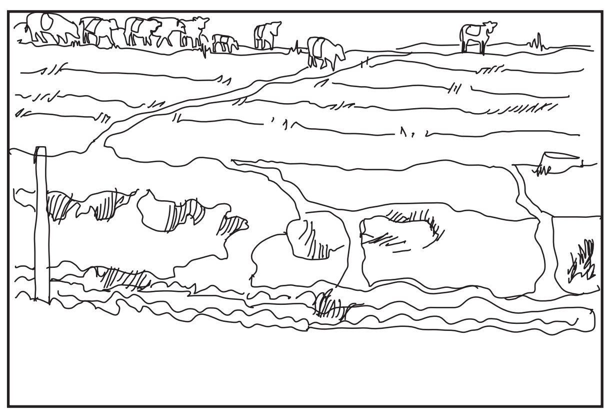




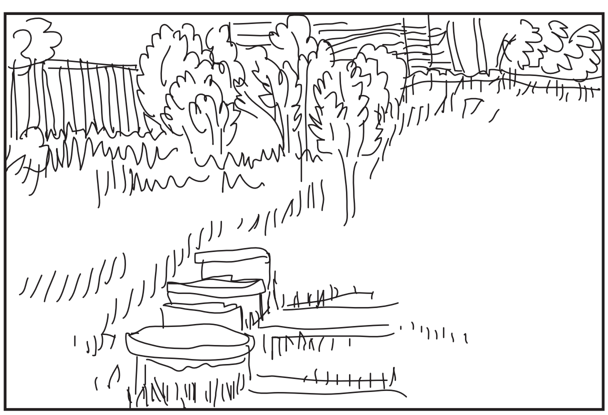
Suburban developments bring vast acres of turf grass, roads, driveways, roofs and parking lots, impervious surfaces which keep rain and snow from soaking into the soil, instead sending it quickly across the surface, carrying road salt, oils and pollutants unfiltered into streams and rivers.

On a farm, livestock waste, fertilizers and weed killers can wash into streams, putting bacteria, nutrients and chemicals into the water.

Planting crops, letting livestock graze and mowing too close to streambanks lets soil erode into the stream, sending sediment into the system.



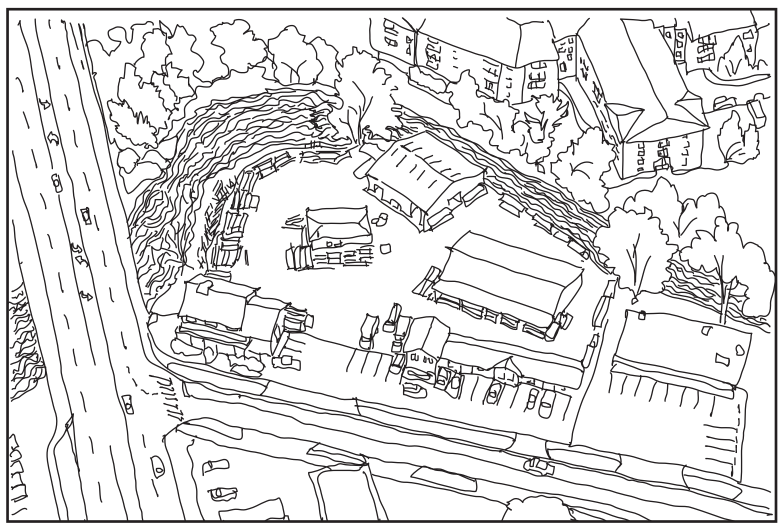
Rural homes without sewers use septic systems to treat human waste . Unmaintained septic systems let untreated waste carry bacteria into ground water.



Watersheds and the Built Environment
Systems out of balance

One watershed, many ways to use the land, and every land use has a positive or negative effect on how stormwater moves through the system. Everything that is built on the land changes how the system works. Every time the land itself is reshaped with berms and basins, or the soil is stripped and compacted, it changes how the system works. Every time a forested area is converted to turf grass or managed landscape, it changes how the system works. Every time a wetland or floodplain is built over, it changes how the system works. Build in a floodplain, and the consequences can be dire.

The more the community upstream paves, the more flooding you get. The more you pave, the more flooding our downstream neighbors get. A new development half a mile up-stream in the watershed can make your property flood and put your neighborhood into a floodplain that didn't even exist before urbanization.



Before...

...and after
(yes, it's the same place.)

The System in the Built Environment

When the natural infrastructure is altered, either the functions of the system are no longer performed, or a structural imitation is engineered to attempt to provide those services. Because the imitation is not designed as original system equipment, it is expensive to maintain, breaks down, and it never quite does the job as well as the original component.

- CAPTURE

The first capture mechanisms, ponds and wetlands, are filled in, so they no longer capture and hold water (which was the intended purpose of filling them in the first place.)

The second mechanisms, plants, soils and especially forests, are cut down or scraped away to make room for structures and paved areas.

Some developments are required to include retention basins to capture and temporarily hold stormwater, but unless they are large enough and are naturalized, they are simply grassy bowls with outlet pipes to the stream or storm sewer at the bottom. They hardly "retain" anything, and the turf growing on hardpacked soil doesn't allow infiltration, so they are more about detention than retention.

The most troublesome structures designed to capture and hold water in place, or hold it back temporarily, are dams. They also hold back sediment that the river needs in order to build and balance downstream reaches, and they keep fish from completing seasonal spawning migrations.

- FILTRATION

Surfaces are covered with hard, impervious paving, roofs and nearly-impervious turf grass, so water cannot filter down into the soil.

Soils get compacted during construction and often the topsoil is scraped off, leaving hard packed subsoil without an open structure that would accommodate infiltration.

- STORAGE

If water cannot be captured in surface storage wetlands, lakes and ponds, or held in soils, and compacted soils don't allow infiltration, water cannot seep down through the surface to recharge underground aquifers.

- CONVEYANCE

The one thing a built environment with vast areas of impervious surfaces does very well is convey. In fact, that's all it does. As water hits the surface, and snowpack melts, it runs off the surface into storm sewers and then into streams, or directly over the streambank. So much enters the system this way, so quickly, with such force that streams and sewers are overwhelmed and flooding occurs. And the fast-moving water scours fertilizers and pesticides off the surface, along with petrochemicals on roadways and all sorts of debris, as well as eroded soils, and dumps it into streams to significantly alter the habitats where aquatic creatures must try to adapt.

The vertical conveyance that happens when roots absorb water, filter out pollutants, bring it into leaves and evapotranspiration breathes it out into the atmosphere, is reduced when the number of trees and the volume of plant material is reduced. Under some conditions, and as temperatures warm, more water evaporates off paved surfaces, so rainfall increases and a feedback loop of more rain, more runoff, more evaporation is created.

A Matter of Energy

The shape of the land and the texture of the surface have the greatest effect on the volume and energy with which water flows throughout a watershed. Flat areas hold more water, hilly and mountainous areas allow water to flow more quickly. Soft and permeable surfaces hold water, hard impervious surfaces allow water to flow more quickly.

Natural surfaces tend to be soft, with vegetation acting as buffers and slowing down movement across the surface so water can filter down into the soil and the subsurface storage areas. Built structures tend to be hard and fast, allowing no delay in water's movement across the surface and into the stream system.

Changing the topography changes where and how fast water flows

Alter the shape of the land and you send more water to new places that may not be designed to manage it. At the same time you deprive the original destination of water it has depended on and built habitat around.

The most common change of topography is when wetlands and other depressions are drained and filled to level the surface for development. If the water can no longer pool and collect in these low spots, it's going to spread out. Since water is ruled by gravity, it will still seek a lower spot. Often, that's the nearest basement.

Eventually it will find a suitable route and begin to carve a new stream channel. Too often that happens in an inconvenient place for the human neighbors, so efforts are made to fill or cover or channel it elsewhere. In a watershed, there really is no elsewhere.

Channelization is another common practice wherein a stream is straightened or walled or both, in an attempt to move water out of an area or keep it from overflowing its banks. Concentrating the stream flow into this constricted space makes it run fuller and faster, and it may reduce erosion for a short time, at the channelled spot; it wreaks havoc on downstream stretches, leading to flooding and erosion.

Changing the surface changes where and how fast water flows

Alter the surface characteristics of the land and you also change the water's route, volume and speed. Replace soft, permeable surfaces with hard impervious ones and you send torrents of water rushing across the surface at high speed. At the same time you deprive the undergroud aquifers of water for long-term storage needs.

The most obvious change of surface is the switch to roads, roofs and parking lots. A less obvious impervious surface is the vast acres of lawn. Turf grass is only marginally less impervious than asphalt. Mow to the edge of the stream and you'll see how shallow the root system is and how quickly lawn and the soil beneath it can erode.

The surfaces of the culverts and pipes and channels in which we confine streams is just as speed-inducing a surface as a flat area of asphalt – worse, in fact, for it offers nowhere for water to spread out to dissipate some of the energy.

Systems
energy and life

More and more streams, especially headwaters and the smallest primary headwater streams, are filled in or confined in pipes. Those waterways cease to function as streams.

Loss of habitat...

The smallest streams that were the nurseries for aquatic life and the primary processors of organic materials that support the food chain no longer exist.

Only the most rudimentary creatures can survive – algae thrives with all the unfiltered nutrients from waste and fertilizer coming into the stream; and with no habitat to support the aquatic life that feeds on algae, blooms can quickly overtake an area. Carried finally into the larger stream or river or lake, dying algae consume vast amounts of oxygen and create dead zones where fish cannot survive.

Suburban landscapes are monocultures – grass farms – mown to stream edges, with exotic species replacing natives, using more fertilizers, herbicides and pesticides. The result is a breakdown of food webs due to removal of habitats.

Water coming off pavement in summer is warmer than it would be if it had been tempered and filtered through soils and root systems, putting cool water species and the whole cool water food web at risk.

Loss of storage space...

Nature provides storage space to moderate heavy flow and to hold water in reserve in wetlands and ponds. Those are the first watershed features to go when an area is slated for development. Farmers were the first to drain and fill wetlands for cropland, easier than cutting down a forest. Many of the marsh-type wetlands had been forest that native hunter-gatherers burned to make it easier to hunt game.

The more we pave over wetlands and fill storage space, and remove topsoil that holds water and cut down deep-rooted forests, the more we remove the natural water storage infrastructure.

The thing about basements...

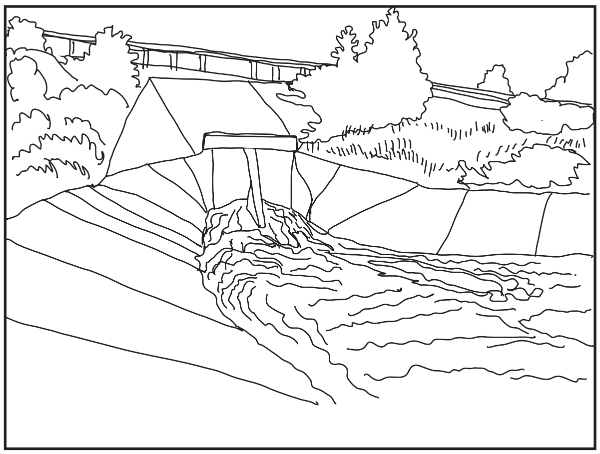
The ground stores water. That's what the water table is, water held underground in soil and rock layers. We are losing storage in the form of wetland every day, but every time we build a new home with a basement, we are also depriving the watershed of a storage area the size of one floor of the house. The area that is excavated for that basement, which used to store water, is now lined with cinderblock and waterproofing to create a sealed hole in the ground. Where is that water supposed to go?

Imbalance in watersheds is as much about reduced storage capacity as it is about increased flow.

Energy
velocity and volume

Hard impervious concrete, asphalt, mortared pavers, roof shingles, are at once the most visible and the most effective way of throwing a watershed out of balance. That creates the problem, but then we make matters worse by forcing the stream to handle more water while not allowing it to remodel itself to hold more water or to use additional land (flood plains) to store overflow.

Too much, too fast..



A stream has two ways to accommodate increased volume: it can make itself larger by cutting down into its bed or carving meanders, or it can send extra water and sediment out over its banks into temporary storage in its floodplain.

We build all kinds of structures to keep streams from doing just those things. By constricting the width, channelizing the waterway and concentrating the energy, we increase stormwater's energy instead of allowing the stream to dissipate it naturally.

Loss of emergency release options...

Sometimes a stream will overflow. That's what streams do. But we like to live near the water, and so we pretend that a stream ends at its banks. In reality, a stream is also the floodplain on either side of the banks.

In heavily urbanized areas, and sometimes even in not-so-urbanized settings, we wall in the stream by literally putting it in a channel and straightening its curves so that it can move the water out faster. Then, when the really big rains come, the water just zooms down the channel and somewhere downstream it reaches a point where it overflows. Floods. Destroys things.

No room to maneuver...

As the watershed is built over, and more water comes overland into the stream, that stream needs to be able to use the full width of its natural floodplain to create meandering curves that make the stream effectively longer though it may cover the same distance as the crow flies. That allows it to hold more water.

When we build so close to, and even within, the floodplain, we keep the stream from doing its own erosion/deposition remodeling work. And when the backyard stream starts meandering too close to our patio for comfort, we line the banks with rocks thinking it will shore them up, when in fact it makes matters worse, especially for the downstream neighbors.

Habitat

exotic invaders conquer natives

The turf grass lawn has become the preferred "natural" surface cover for more than fifty million acres of the United States, according to industry figures, including residential and commercial lawns, parks, golf courses. Imported and hybridized species of trees, shrubs and flowering plants are all over the place. Unfortunately, the lawn is a monoculture that is expensive to maintain, and the lovely uniform plantings have crowded out native plants that provide food and shelter to native wildlife.

Turf grass –

Turf grass does sequester carbon, promote evaporation and reduce erosion. But the benefits of these functions must be weighed against the costs of vast acres of surfaces that are only marginally more permeable than paving, and use vast amounts of fertilizers, pesticides, herbicides and fossil fuels to green, debug and mow.

Most of the nutrients that wash into storm drains and streams come from lawns. Surreptitious dumping of grass clippings into streams adds to the problem. The lawn-owner's penchant for mowing right up to the edge of a stream or river removes any vegetation that might prevent this nutrient loading and might stabilize the stream bank. Turf grasses' four-inch root depth is not enough to prevent erosion along stream banks, and it can't compare to native grasses and plants whose roots are measured in feet, not inches.

Exotic and Invasive species –

In a battle between natives and newcomers, you would think that the home team would have an advantage and successfully defend its territory most of the time. Unfortunately, that's not what happens. Instead, the evil (albeit often quite beautiful) alien invaders arrive to a place where there is no natural predator to control their populations. Native species, both of plants and animals, fit into a life web where population is controlled by predators and by the availability of food and water.

The problem with exotics and invasives is that they crowd out or starve out or otherwise take the place of native plants that supply the food and shelter that native animals require. If wildlife isn't nourished by berries or supported by habitat the invasives offer, we lose those species, too. Some of the invasive plant species can take over entire streams or cover entire wetlands, ponds or lagoons.

Most exotics are brought into the system by well-meaning gardeners just trying to prettify their landscapes. To make room, they clear away natives, like, for example, milkweed. And then they wonder where all the monarch butterflies went. (Monarchs migrate to northern climes because that's the only place where milkweed grows, and milkweed is the only plant they'll lay their eggs on because it's the only plant their larvae eat.)

Imagine someone coming into your home and filling your refrigerator with food you can't eat but they can, and taking out all your food to make room for theirs. You'd starve, they'd thrive. And it turns out their food takes a lot more water and fertilizer to grow than natives.

Dams

obstacles to healthy rivers

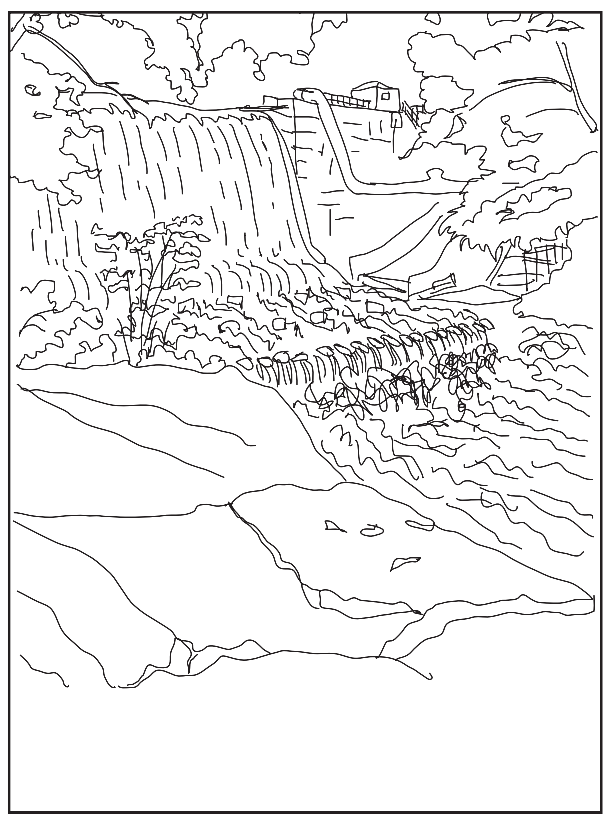
Dams prevent rivers from moving sediment freely, and they impede fish passage, especially problematic during seasonal migrations.

Many of the dams in place today create reservoirs for recreation or the storage of drinking water. Some hold back a limited amount of water to divert a portion of flow for irrigation or other purposes. Some generate electricity and some are remnants of an age when water ran mills and powered machinery.

There are many dams that don't serve any modern purpose. Yet they cause problems for rivers that affect the waterway's ability to manage flow and provide habitat.

Large amounts of sediment collect behind a dam, material that otherwise would wash downstream, carry nutrients, and be used to shape and build riverbanks or to moderate flow.

Fish cannot move upstream past dams to spawn, limiting the diversity of species and populations of fish and changing how the food web works.



Streams

pollution overload - nice lawn, salty roads, sickly river

Water quality changes dramatically when human habits and built infrastructure enter the picture. In addition to the changes in flow and energy, the chemistry of streams changes as new ingredients are added to the system.

We've seen how a river or stream has different parts that act differently – pools, runs, riffles – or move more quickly or slowly, or host more habitat or less. The movement of a stream also affects how it processes pollution, whether that pollution is too much fertilizer or too much motor oil. It's another of the stream's balancing acts.

The increases in pollution that come from built environments can quickly throw the stream out of chemical balance.

Rugs on drugs...

Lawncare is all about having bright green lawns with no weeds. To make that happen, tons of fertilizer and herbicides are spread over millions of acres of turf grass every year. This doesn't even include crop fertilization in farmland, but that also runs off into nearby streams and challenges the water system's ability to process pollution.

In areas where lawns are divided by driveways or where nutrients are spread near impervious surfaces, the extra material that falls on the hard surface goes directly into the stream via runoff or through storm sewers.

Devious dumpers...

Many landowners treat streams, rivers, ponds and lakes as their personal disposal systems, dumping everything from grass clippings to gas or oil left over from the end-of-season lawnmower maintenance into the system.

Yard waste, including grass clippings and leaves, decomposes and returns the nitrogen, phosphorous and potassium that fed it into the stream. Algae feast on it, and at the end of their lifecycle their decomposition takes so much oxygen out of the water that there's not enough for fish or other creatures.

Salt is a serious subject...

Road salt kills trees and plants, so it reduces the health and amount of available habitat.

If it stays in the stream- or lakebed, it can reduce the oxygen and increase the effects of nutrient loading from the sources we just described. So just as salt on food intensifies the flavor, salt in streams intensifies the negative effects of other pollution to the point where it decreases dissolved oxygen, and, again: no oxygen, no stream life.

Septic soups...

The waste that humans and animals produce doesn't necessarily get filtered through soils or digested and filtered through microbacteria. Poorly maintained septic systems, indisriminate livestock deposits and overspreading of manure on agricultural lands put streams at risk. As beneficial to crops on land as manure can be, the same nutrients are pollutants when they get in the stream. Ammonia, a main ingredient in manure, is toxic to fish, even in tiny quantities.

On the large scale, where municipal wastewater treatment systems – sewer systems – handle miles of storm sewers, many still use Combined Sewer Overflow (CSO) systems that dump untreated sanitary waste into streams, rivers and lakes when stormwater overwhelms the treatment plant's capacity.

Dog waste that isn't collected by dogwalkers gets carried into catchbasins before it has a chance to decompose into the soil where it was deposited. Some lovely parks have terrible quality in their pondwaters and streams. Often they mow very close to the water because their visitors want access. Canada geese populations are a problem in the northern regions, and they congregate along the water's edge.

A prescription for trouble...

The newest wrinkle in the clean water world centers around what happens to all the chemicals that go into the shampoos and perfumes and lotions we use, the sunscreen we slather on, the prescriptions we take, and the supplements we swallow? Individually they may be safe – for humans – but we have no idea what happens when they get flushed out with the waste and combine in the sanitary sewer solution.

If the disclaimers on televised pharmaceutical advertisements are any indication, there are potentially disastrous consequences associated with just taking some drugs by themselves. Imagine the effect they could have on aquatic life. And, since even modern water treatment plants aren't designed to filter out all the individual ingredients, let alone combinations, the issue of PPCPs, Pharmaceutical and Personal Care Products, is a new area of study and concern. After all, we drink this water.

Litter is trashing our streams...

Litter has been a problem since the first disposable package was invented. Archaeologists are still digging up clay jugs and glass bottles, which goes to prove that even if something is made of a "natural" material, that doesn't mean it's biodegradable.

Nowadays stewardship groups spend more time collecting plastic bags and bottles from streams, along with the occasional shopping cart, foam cup and fast food bag. Plastic doesn't go away, and it floats, so it's killing fish in the streams and lakes here and in oceans a world away.

Restoring the System
Balanced Growth Planning

Now we know what the natural infrastructure is supposed to look like, and how it should work.

We've learned how some of our land use decisions and structural solutions sometimes put the system out of balance and make things worse.

Now it's up to us to use this knowledge to shift operations back into balance.

One way to do that is to broaden our vision of what should be included in a community's land use, or master plan. Traditionally, planners have looked at a map, sought open spaces, preferably flat, targeted those for development and looked more at hardscapes than at clean water or greenspace needs.

In the 21st Century, we're dealing with stormwater runoff, water quality issues and environmental health as they affect our quality of life and economic well-being. Sustainable communities conserve and use the natural systems that are in place, and identify development locations that do not harm the functioning of those systems.

Balanced Growth Planning is the way sustainable communities do their land use planning.

Restoring the System
Balanced Growth Planning

As long as we live on this land, our watersheds will never function as they did before we added our structures, roads and buildings. But even though we can't fully return to nature's way, we can bring our watersheds into a more balanced and healthy state.

And we can grow our communities without throwing the natural systems out of balance. First we look toward restoration to bring us back in balance, then we look at what kind of development belongs where, and where development doesn't belong at all.

Restoration requires the cooperation of governments and citizens, and since a watershed almost always covers more than one municipality, that means engaging the governments of all the localities that share the watershed.

This is the basis of Balanced Growth Planning –

- First, identifying, evaluating and prioritizing the communities' issues and needs – e.g. frequent flooding, severe erosion, loss of forest canopy;
- Second, taking an inventory and creating a GIS data analysis of current watershed conditions, especially the critical features that are most important in the functioning of the watershed system, such as riparian buffers, wetlands or critical soils;
- Third, correlating the critical features analysis with community needs, and developing criteria for designating Priority Conservation Areas (PCA) and Priority Development Areas (PDA);
- Fourth, identifying areas of undeveloped land with relation to the critical natural features to be found there, and
- Fifth, assigning Priority Development Area, Priority Conservation Area or in some cases Priority Restoration Area status to each area, and creating The Map .

Finally, to move the initiative from plan to action, participants create and prioritize a list of tools and practices that offer the communities various ways in which to meet the goals. Some would be carried out in land use and planning commissions, some are site-specific design issues, while others will surely be most effective as regulations. Some strategies, such as cooperative planning and consistent building and zoning codes across all watershed partner communities, would be more in the purview of inter-community relations.

Before you can start along the Balanced Growth path, of course, you must have broad and meaningful representation from government and citizenry in all the communities who share the watershed. This alone is an important step in moving toward a regional collaborative stewardship of common resources.

And once you have moved into the action phase, your community can and should integrate the PCA/PDA map into its master plan.

A slight change in the plan

First we need a new master plan, because the old one isn't working, or keeps needing to be "tweaked." Perhaps the ground rules have changed in terms of economics, or due to a public demand for more greenspace preservation, or a spate of flooding or erosion and the subsequent repairs are breaking the bank.

The Balanced Growth Planning process gives you all the tools and strategies to rethink your plan and remap your map. The new map defines where things can be built without interfering with the natural system, and where not to build. If you build in the former areas, you can save headaches and dollars. If you build in the latter areas, you'll know to expect problems.

The Map should be adopted as a part of your master plan.

A Watershed Management Plan should be adopted, using the Preferred Strategies outcomes of the BGI process as a basis for action. The BGI plan says where the assets and features are that need to be protected or restored. The Watershed Management Plan says what strategies should be used where and when, to conserve and restore the watershed functions.

Cracking the code

The goal is to restore and support the natural functioning of the watershed system.

Changing a community's ways is not easy, but there's a tried and true set of steps to follow: Set the goals, put policies in place and follow up with regulations if need be.

Some of the work will come through policies that encourage the use of best management practices. They do not have the force of law, but if taken seriously they do have force. Policies can be hugely effective in setting a community's standards, e.g. "We will reduce our landscape maintenance department's use of fertilizer and pesticide by half. We will naturalize all riparian corridors on public land. We will use permeable paving whenever we have to replace paving on public property."

Some of the work will come through changes in the zoning code for zoning issues, site plans and location and design permitting, and in the building code for Low Impact Design elements. In many cases, there are legislative barriers or obstacles that simple need to be removed in order to allow property owners to follow watershed stewardship strategies. If your code has provisions for green roofs, rainbarrels and cisterns, rain gardens, and permeable paving, it makes it easier for users to implement them without having to seek variances from the Board of Zoning Appeals.

Restoring the System
Beneficial Practices

So it comes time to act, or in some cases to cease acting. Some problems can be corrected not by doing something new, but by ceasing to do things the old way.

In this section we offer practical suggestions for communities and we show how the strategies can be undertaken by various members of the community, from city hall to citizens' backyards.

Think About This:

Permeable paving can reduce the amount of road salt you use. As it allows water to percolate down into sub-surface storage layers there is less water on the surface left to freeze. Even filter strips in otherwise impervious paving will help reduce ice cover.

That's good for the budget and good for the stream.

REDUCE IMPERVIOUS SURFACES

Replace impervious surfaces with ones that allow infiltration

KEY BENEFITS of Reducing Imperviousness

- Reduces flooding by increasing infiltration, reducing volume and energy of surface flow
- Reduces nonpoint source pollution and sedimentation in streams
- Recharges groundwater
- Allows water to be filtered and cleaned before entering groundwater system

IMPERVIOUS SURFACES are the bane of watershed health and function. They include the obvious – paved roads, sidewalks, driveways and parking lots, roofs, patios and walkways – as well as less-obvious surfaces such as turf grass. The traditional turf lawn, when cut short, is considered to be impervious because more water runs off its surface than seeps down into the soil, especially during heavy rain or snow melt.

The first problem with impervious surfaces is the one most people notice during or after storms: Large volumes of water rush across the surface, and whether the runoff enters streams directly or gathers in storm sewers, it's a lot of water moving very quickly. The extra volume, moving at high velocity, can overload streams and degrade stream banks. The heavy, fast load also puts stress on older sewer systems and sewage treatment plants served with Combined Sewer Overflows (CSOs) designed to release untreated waste into streams when the volume through the lines threatens to overwhelm the treatment plant's capacity.

The increased flow erodes critical soils and creates sediment, which fills streambeds and makes streams more shallow and able to hold less water. As peak discharges move downstream, flow accumulates and energy increases, until banks overflow and flooding occurs. Upstream, where streams are shallow and banks are low, flood plains may accommodate overflows, but downstream, the accumulated flow can cause serious damage to life and property.

Second, when rainfall and snowmelt cannot infiltrate into the soil, they carry surface pollutants – automotive fluids that leak and concentrate on parking areas, road salt, asphalt wearing off roof shingles, lawn fertilizers and pesticides – either directly into the stream or into storm sewers that discharge into streams. This pollution and nutrient load degrades water quality. The sediment added by eroded soils can smother aquatic life and reduce the system's ability to absorb and manage pollutants.

Third, impervious surfaces that keep water flowing aboveground rob aquifers of water needed to recharge the ground water system. These underground rock "sponges" are not only the source of well water and springs, they provide support to the layers of earth and rock above them – they support the surface, but only when they hold water.

REDUCE IMPERVIOUS SURFACES
strategies, roles and actions

Strategies to reduce imperviousness and improve infiltration include:

- using permeable paving materials wherever possible, or installing filter strips of pervious paving, gravel, or vegetated planting beds along the water's route, to interrupt surface flow and allow water to infiltrate;
- reducing areas of dense turf grass and replacing with more natural grasses and ground covers that allow soils to remain loose and permeable, or letting grass grow higher so that it can slow flow and absorb more water;
- installing rain gardens and/or bioswales to catch and hold runoff and allow it to filter slowly into the ground;
- allowing large areas to revert to meadows, where plants can manage surface flow;
- expanding forested areas that not only interrupt heavy rainfall on its way to earth, but have great abilities to absorb water and direct infiltration deeply into soils;
- reduce soil compaction during construction by limiting access routes for construction vehicles;
- install roof gardens on flat roofs, which can significantly reduce runoff.

KEY ROLES	KEY ACTIONS
Administration Economic Development & Community Development Departments	• Use permeable paving on municipal property and projects, limit increase of impervious surfaces on public land - set an example by using public lands as demonstration sites for new materials and methods. • Provide incentives for limiting impervious surfaces on new development and redevelopment. • Encourage Low Impact Development practices, green roofs, and other green building design features.
Legislators & Planning Commissions	• Include by right in building codes: permeable paving, filter strips, bioswales, rain gardens, green roofs, higher mowing heights and other best management practices that improve or increase infiltration of water into soils or subsurface storage areas or otherwise mitigate surface runoff. • Allow naturalization of previously-paved surfaces (parking lots and paved pads on abandoned properties; removing disintegrated paving surfaces and planting native grasses on portions of parking lots.) • Revise building codes to state maximum number of parking spaces allowed rather than minimum number required: require greater tree planting ratio per space and require a minimum percentage of space to be pervious surface or bioretention areas. • Preserve budgets for forest management and expansion.

KEY ROLES	KEY ACTIONS
Zoning Appeals Boards	• Deny variances that increase impervious surfaces; • Require mitigation via a comparable on-site infiltration area or conversion from impervious to pervious surface (e.g. increased roof area can be mitigated by converting an existing patio area or walkway from concrete to pervious pavers.)
Service and Engineering	• Use pervious pavement, pavers, gravel on municipal construction projects. • Place signage at locations where BMPs are used, to educate public.
Developers	• Build vertically rather than horizontally, with parking under buildings. • Use "spray gutters" or "rain chains" rather than downspouts to reduce flow off roofs into storm sewers. • Install permeable paving, filter strips, rain gardens, natural surfaces whenever and wherever possible. • Keep impervious surfaces to a minimum.
Stewardship Groups	• Educate homeowners and landowners. • Encourage reduction of impervious surfaces. • Work with local Soil & Water Conservation services to host workshops or tours to demostrate or showcase pervious surface options. • Showcase local businesses that install pervious paving, filter strips, etc. • Advocate the proactive use by your local government of Low Impact Development, Best Management Practices and innovative methods for improving infiltration on public land, and building and zoning code changes that enable such practices and materials. • Work to "de-pave" and naturalize abandoned parking lots and roadways.
Individuals	• Remove or replace impervious surfaces with permeable paving, pavers, plantings, etc., whether it's whole driveways or just blocks, edges or crosswise strips.

Think About This:

Abundant, healthy wetlands can be prime recreational and tourism locations for today's communities, educational assets for science programs and economic development tools.

They attract large numbers and great varieties of birds and other wildlife...and people. The U.S. Fish & Wildlife Service's 2009 study shows that 20% of Americans are birdwatchers.

PRESERVE, RESTORE and IMPROVE WETLANDS

Wetlands are the most valuable pieces of the storage and filtration system

KEY BENEFITS of Preserving, Restoring and Improving Wetlands

- Provides short-term storage for large volumes of water
- Reduces flooding by retaining water, allowing evaporation and slowly releasing into stream systems
- Reduces bacterial pollution in streams and along beaches by diverting large amounts of stormwater from overburdened wastewater treatment plants that use combined sewer overflows
- Serves as home to diverse wildlife populations that provide pest management to surrounding areas
- Filters and cleans water before discharging into water supply

Conservation of wetlands may be the single most important effort a community can adopt to manage large volumes of surface water and retain the integrity of the watershed system – not simply because of the storage function they perform, but because of the speed at which these valuable pieces of land are being destroyed.

A wetland is a natural water storage and filtration facility, and at the same time it supports the most varied wildlife habitat, and therefore populations, likely to remain in otherwise urban- and suburbanized regions.

The broad range of beneficial services provided by wetlands cannot be duplicated by any single man-made structure, including the retention basins now a ubiquitous part of any recently-developed landscape. A wetland is not merely a big hole, and it is definitely not a big turf-covered depression in an otherwise turfgrass field. Water treatment plants can imitate filtration services to some degree, but they require major investments to replace a function nature does for free. And these plants are overloaded because wetlands are no longer holding stormwater out of the system.

Wetlands are defined as areas saturated by water long enough or often enough to support vegetation adapted for life in saturated soil. In other words, they are ecosystems containing certain specific types of soils that manage water in a unique way, and support certain collections of plants that provide habitat for certain groups of wildlife, aquatic, terrestrial, insect and avian. Thus, they cannot easily be replaced.

Flooding and stress on streams can be directly attributed to the loss of wetlands and other storage areas. A healthy watershed has many of these “holding areas” distributed widely throughout its basin. Some will be marshes, or bogs, some will be forested, but all are critical to healthy watershed function.

And the best part is...they don’t have to be built, they just have to be left alone.

PRESERVE, RESTORE and IMPROVE WETLANDS

Strategies to preserve, restore and improve wetlands include:

- placing wetlands in conservation easements to insure that the services of the wetland are retained for the community over the long term;
- instituting ample setbacks in zoning and building codes
- strictly limiting allowable uses within setbacks, prohibiting mowing or recreational use
- prohibiting diversion of water out of wetland other than what naturally takes place

WETLAND SETBACKS

For wetlands that are located along a stream and fall within the riparian corridor, a properly sized riparian setback will completely include the wetlands plus:

- a 50-foot setback extending beyond the outer boundary of a category 3 (high quality) wetland and
- a 30-foot setback extending beyond the outer boundary of a category 2 (mid-quality) wetland.

Category 1 wetlands, which are of such low quality that they are not considered critical for purposes of habitat or function, may still be protected with a setback, marking areas that could be improved to category 2 wetlands.

Isolated wetlands located away from streams should be afforded the same setbacks. These are the wetlands that face the greatest threats from development, and therefore need the most protection.

KEY ROLES	KEY ACTIONS
Administration, Economic Development, Community Development	• Create incentives for preservation and improvement of existing wetlands, and restoration of category 1 wetlands to provide same-watershed mitigation sites. • Own the property or hold the conservation easement and showcase as an element of parks and/or education.

Legislators,
Planning Commissions
	• Include Wetland Setbacks in zoning .
	• Apply the setback to all category 2 and 3 wetlands, and on a selective basis to category 1 wetlands (even if only as flood control resources.)
	• Design setback codes to:
	  • Conform to minimum widths and recommended distances for the wetland type, quality and surroundings.
	  • Include 100 year floodplains.
	  • Include variance and mitigation provisions to keep function within the same watershed.
	  • Provide for inspection and enforcement.

PRESERVE, RESTORE and IMPROVE WETLANDS

KEY ROLES	KEY ACTIONS
Zoning Appeals Boards	• Enforce wetland protection codes.
Service, Engineering, Building Inspectors	• Observe Clean Water Act regulations and enforce US Army Corps of Engineers permits. • Install barrier/protection fencing immediately upon permit request, at appropriate setback plus additional buffer, and around trees at ample distance to protect roots. • Monitor construction sites closely for deviation from approved plans. • Require construction vehicles to stay proper distances away from wetlands to reduce compaction and to avoid bringing invasive species into area on tire treads. • If access is required, opt for boardwalk built with minimally-invasive construction techniques rather than a causewalk.
Residents, Business Owners and Property Owners or Managers	• View wetlands as enhancements and scenic, educational or recreational resources. • Maintain a dense buffer of native vegetation between any paved surfaces and the wetland. • Do not plant invasive species where seeds can be blown or washed into wetlands (don't plant purple loosestrife!)
Developers	• Recognize the value of wetlands and preserve whenever possible. • Mitigate lost wetlands on site when possible. • Building "up" rather than "out" can help you use a site footprint limited by setback requirements. • Respect permit requirements, keep construction vehicles far away.
Stewardship Groups	• Use wetlands as educational resources. • Create a guide to birds and animals that live in or visit the wetland. • Raise funds and work with landowners, city governments, state agencies, land conservancies and others to conserve strategic wetlands.

{ Think About This:

Floodplains can be of value to landowners even when the area cannot be built upon. Conservation Easements can provide remuneration and tax incentives when land is set aside for nature in perpetuity. }

CONSERVE FLOODPLAINS

Because sometimes a stream needs a little extra room

KEY BENEFITS of Conserving Floodplains

- Provides short term storage for excess water
- Reduces flow rates and velocity by passing flow through vegetation
- Allows sediment and nutrients to stay on, or return to, land
- Provides filtration services for runoff
- Provides habitat for aquatic and terrestrial life
- Keeps people and structures out of harm's way
- Helps to preserve riparian ecosystems
- Can be combined with riparian buffer protection to create linear greenways

FLOODPLAINS are the low-lying flat lands that border streams and rivers. When a stream reaches its capacity and overflows its channel after storm events, the floodplain provides for storage and conveyance of these excess flows.

Floodplain areas should be avoided when siting homes and other structures, to minimize risk to human life and property and to allow the natural stream corridor to accommodate floods.

In their natural state they reduce flood velocities and peak flow rates by passing flows through dense vegetation. Floodplains also play an important role in reducing sedimentation and filtering runoff, and provide habitat for both aquatic and terrestrial life.

Development in floodplain areas can reduce the ability of the floodplain to convey stormwater, potentially causing safety problems or significant damage locally, as well as to both upstream and downstream properties. Most communities regulate the use of floodplain areas to minimize the risk to human life as well as to avoid flood damage to structures and property.

Floodplain protection is complementary to riparian corridor preservation. Both of these better site design practices preserve stream corridors in a natural state and allow for the protection of vegetation and habitat. Depending on the site topography, 100-year floodplain boundaries may lie inside the riparian setback, while in other cases the riparian corridor should extend outward to meet the flood zone boundary.

CONSERVE FLOODPLAINS

Strategies to Conserve Floodplains include:

- Preserving generous riparian setbacks and encouraging property owners to plant and maintain vegetation
- Using flood zone maps as part of zoning maps and prohibiting building within zone
- Incorporating flood plains into public park areas, especially as greenways

KEY ROLES	KEY ACTIONS
Administration, Economic Development, Community Development	• Support floodplain preservation with policies that support generous setbacks and encourage landowners to vegetate and maintain riparian corridors and floodplains. • Focus development in areas where they will have the least impact. • Encourage developers to design sites with structures away from flood plains, and with pervious surfaces and dense, natural landscaping close to flood plain boundaries. • Work with upstream and downstream communities to collaborate on balancing the amount of flood plain along the entire stream.
Legislators, Planning Commissions	• Incorporate the most up-to-date flood plain maps into zoning and building codes. • Recognize that increased impervious surfaces in one area will have the effect of enlarging flood plains of downstream areas. • Provide incentives or relief to landowners in areas where floodplains create unbuildable areas. • Allow increased density on development sites in lowest-impact areas in exchange for no development in flood plains. • Change codes to allow taller plant growth in flood plains.

CONSERVE FLOODPLAINS

KEY ROLES	KEY ACTIONS
Zoning Appeals Boards	• Respect floodplain boundaries. • Recognize that variances allowing structures to encroach on floodplains will inevitably create problems.
Service and Engineering	• Use structural flood management systems only as complements to natural systems. • Reduce channelization and culverts upstream so that floodplains downstream can handle increased loads. • Keep riparian areas and flood plains vegetated by reducing mowing.
Residents, Business Owners and Property Owners or Managers	• Be aware that solutions to "rush and flush" water off your land will invariably create flooding problems downstream. • Accept the fact that streams will flood on occasion, and keep any structural solutions such as berms or dikes as far from the stream and as close to your buildings as possible. • Use permeable paving surfaces in areas near flood zones to increase the speed at which the water infiltrates into soils. • Let vegetation grow higher along flood plains.
Developers	• Design sites so as to leave plenty of room beside flood plains. • Keep areas along flood plain boundaries heavily vegetated. • Use permeable paving throughout the site, and include vegetated areas to hold excess water (rain gardens, etc.)
Stewardship Groups	• Educate and work with property owners to convert flood plains to conservation easements.

Think About This:

Restoration and improvement of riparian zones could be income opportunities for entrepreneurs who package and install appropriate native vegetation for property owners.

Communities could use riparian areas as beneficiaries of forest mitigation, as payment for trees and vegetation removed for development.

RIPARIAN CORRIDORS

vegetated lands alongside rivers, streams, wetlands and shorelines

KEY BENEFITS of a Riparian Buffer

The buffer and the setback that protects it:

- keep the water feature from being disturbed by land uses, buildings or potentially damaging activity
- when properly vegetated, keep pollutants out of the water and keep soil from eroding into sediment
- protect stream banks from erosion
- provide habitat for wildlife and support healthy aquatic ecosystems
- contain roots that hold soil and filter water, and, if forested, shade streams to keep them the proper temperature for fish and microorganisms to thrive.

The healthiest streams run through uninterrupted forests with multi-layered, diverse vegetation and stable tree canopy. In addition to providing roots to anchor soil and filter stormwater and surface runoff, and shade to moderate stream temperature for aquatic life, vegetated zones keep human activity at bay and allow for flooding to occur without impinging on human structures.

Although trees and forest layers may be removed for development, some of the benefits of forest cover can be retained or restored by designating an area along each streambank as a "no incursion zone" – a riparian buffer.

Riparian Buffers are special types of conservation areas along streams, wetlands or shorelines where development is restricted or prohibited, and **Riparian Setbacks** are specifications in zoning codes that define how far from the streambank or water feature the buffer should extend.

The setback width needed to perform properly will depend on the size of the stream and the surrounding conditions, The setback should be continuous and not interrupted by impervious areas that would allow stormwater to concentrate and flow into the stream without first flowing through the buffer.

Should the 100-year floodplain be wider than the riparian setback on either or both sides of the watercourse, the setback should be extended to the outer edge of the 100-year floodplain.

Development within the riparian buffer should be limited to those structures and facilities that are absolutely necessary. Such limited development should be specifically identified in any codes or ordinances referencing the buffers. When construction activities do occur within the riparian corridor, specific mitigation measures should be required, such as deeper buffers or riparian buffer improvements.

RIPARIAN CORRIDORS

roles and responsibilities for community stewardship

Strategies to Conserve Riparian Corridors include:

- Institute Riparian Setbacks, and include them in all zoning maps and master plans
- Enforce setbacks in permitting and appeals process
- Encourage planting and naturalization, limit incursion, prohibit mowing
- Obtain conservation easements where possible

KEY ROLES — KEY ACTIONS

Administration

Economic Development & Community Development Departments

- Create incentives for preservation and improvement of existing vegetated buffers, and restoration of areas where riparian plantings have been lost.
- Include cluster-type “conservation developments” that allow the community to make beneficial use of, and use as a marketing tool, existing or enhanced natural recreation areas.

Legislators &

Planning Commissions

- Include Riparian Setbacks in zoning.
- Publish setback map and distribute to all affected landowners.
- Apply the setback to all designated watercourses in the community.
- Design setback codes to:
  - Conform to minimum widths and recommended distances.
  - Include 100 year floodplain and riparian wetlands.
  - Prohibit construction in riparian corridor.
  - Include variance and mitigation provisions to keep function within the same watershed.
  - Provide for inspection and enforcement.
  - Extend setbacks at least to the 100-year floodplain.

Zoning Appeals Boards

- Respect riparian setback codes and protect them as you would any other piece of the community’s stormwater management system, and be as reluctant to allow incursions into riparian buffer areas as you would be if someone asked permission to dismantle a storm drain or culvert.

Service and Engineering

- Limit incursions into riparian zones when doing structural infrastructure repairs or improvements by adding a “no dig zone” beyond the setback written in the code, and/or use proper protection at zone edges.
- Extend “high mow” and “no mow” zones on public land.
- Reduce the burden on riparian zones adjacent to paved or turf areas, where excessive runoff is common, by using infiltration calculations that reflect the actual soil infiltration conditions in the area.

KEY ROLES / KEY ACTIONS

Tree Commissions

- Institute a forest mitigation program for property owners who remove trees and/or forested areas to replace forest cover in riparian zones.
- Create a forest mitigation land bank and a fund to receive payments in lieu of planting from developers or property owners who remove trees or forest cover:
  - Use the funds to improve riparian areas on public lands,
  - Work with private property owners to restore riparian areas if buffer zones on public land are not available, and
  - In cases where neither of the above solutions are applicable, use the funds to support the city's urban forest/street tree program.

Residential and Commercial Property Owners or Managers

- Plant or improve riparian zones using the full range of forest vegetation – tree canopy, understory trees and shrubs, floor vegetation and ground cover, giving preference to native species and totally avoiding invasive or exotic species.
- Commercial property owners can take advantage of the increase in bird life resulting from healthy riparian areas by working with local birding clubs and producing birdwatchers' guides.

Developers

- Recognize the value of riparian zones and preserve whenever possible.
- Replace or mitigate lost vegetation outside the prescribed setback areas.
- Building "up" rather than "out" can help you use a site footprint limited by setback requirements.

Stewardship Groups
Civic Groups
Student Groups

- Lobby city hall to adopt Riparian Setbacks in the zoning code.
- Support legislators who support conservation development zoning and riparian protection.
- Provide public education on the reasons for riparian corridors and setbacks, and inform property owners about tax incentives and benefits associated with conservation easements.

Think About This:

Expanding a community's forestry program beyond street trees to provide planting and maintenance of trees on private property can improve the city's tree canopy and allow it greater input in the species of trees that populate its watershed.

Providing support and access to natives, and using natives in its tree program, will reduce costs in the long run and increase the services delivered by a healthy canopy.

PRESERVE, RESTORE and EXPAND FOREST COVER

Comprehensive and efficient ways to improve stream health

KEY BENEFITS of Preserving and Expanding Forest Cover

- Roots stabilize soils, while canopy and leaf cover interrupt precipitation to reduce erosion and sedimentation in streams
- Cleans stormwater before releasing into groundwater and streams
- Reduces flooding by absorbing and managing stormwater
- Absorbs airborne pollutants, especially particulates, that would otherwise enter the water system
- Provides wildlife habitat
- Conserves household energy costs
- Increases property values

FOREST COVER includes all the trees, understory plants and ground cover found in a natural forest, and is an essential element in stream health, stormwater management and water quality. Trees help support a community's quality of life by maintaining the proper functions of watersheds.

Riparian zones along streams are the first defense against impacts on stream systems, but forest cover throughout the entire watershed, even in areas distant from streams, contributes significant benefits by absorbing stormwater and intercepting flows before they reach near-stream areas.

The canopy intercepts rainfall and reduces its impact on soils, and keeps soils and streams shaded to support microorganisms and aquatic life. Smaller understory trees, shrubs and ground covers hold soils in place and slow surface runoff. The roots of all the forest vegetation absorb water and hold it in wood, leaf and stem, removing vast amounts of surface water during floods.

Tall trees shade buildings, and dense evergreens shelter them to reduce energy costs. Wooded lots increase property values, increasing the community's asset base. Trees, especially groups of trees, planted throughout parking lots not only reduce runoff, they also shade vehicles from sun. In summer, this reduces the need for idling to cool cars down and reduces both gas consumption and emissions. By absorbing particulates and air pollution, and reducing emissions, this strategy improves air quality in communities, and keeps air pollution from becoming water pollution.

PRESERVE, RESTORE and EXPAND FOREST COVER

Strategies to Restore and Expand Forest Cover include:

- Institute Riparian Setbacks, and include them in all zoning maps and master plans
- Enforce setbacks in permitting and appeals process
- Encourage planting and naturalization, limit incursion, prohibit mowing
- Obtain conservation easements where possible

KEY ROLES	KEY ACTIONS
Administration, Economic Development, Community Development	• Work with private landowners to establish forest mitigation banks of land to accommodate replacement of lost canopy cover. • Recognize the infrastructure value of woodlands and factor into the equation as assets.
Legislators, Planning Commissions	• Establish forest cover goals for your community. American Forests recommends that urban areas strive for 40% canopy overall, 50% canopy in suburban residential areas, 25% canopy in urban residential areas, and 15% canopy in commercial areas. • Goals should reflect both conservation efforts and planned restoration activities on public and private lands. • View forest cover as infrastructure, and provide funds to maintain and improve your urban forest. • Require developers to follow forest cover goals and integrate planting areas into parking lots to reduce runoff.
Zoning Appeals Boards	• Enforce codes that support preservation. • If variances are allowed that remove forest cover, require mitigation.

Building Departments,
Engineering,
Service
	• Apply forest protection provisions at various stages in development:
	  • Preliminary Site Design – Identify high value woodlands for preservation.
	  • Identify specific trees to be preserved and specify protection methods. Measure canopy cover and/or caliper inches of trees to be removed and determine the method of replacing a comparable volume of forest cover on site or in a forest mitigation bank.
	  • Monitor tree/forest health and require maintenance on an ongoing basis post-construction.

PRESERVE, RESTORE and EXPAND FOREST COVER

KEY ROLES	KEY ACTIONS
Tree Commissions	• Educate and encourage landowners to preserve, restore or increase tree and forest cover on private land. • Create a forest mitigation fund where developers or landowners who remove trees, but whose site cannot accommodate replanting, can contribute payments in lieu of planting, and use those funds to plant, improve or maintain tree canopy and forest cover on public lands and rights-of-way.
Developers	• Design sites to include ample forest cover, preferably in areas where they can reduce surface water runoff. • Incorporate trees throughout parking areas to absorb water and shade vehicles. Surround "tree boxes" with pervious paving strips and fashion the boxes or curbs with ground-level holes to allow runoff from paved areas to enter the root system. • Resist the temptation to rake and mulch under trees – use lower level plantings and ground cover that requires minimal maintenance and reduces root disturbance.
Stewardship Groups	• Support forest preservation, and especially increased planting, throughout the community. • Sponsor tree planting events, seedling giveaways, and adopt-a-forest programs. • Work with governments and private landowners to designate planting sites. • Educate landowners, especially in commercial and residential areas, about the importance of letting forested areas "go natural", letting volunteer understory trees, shrubs and vegetation take hold, and allowing leaves to remain to form new soil. Discourage the practice of removing fallen leaves and replacing with store-bought mulch. Let the trees mulch themselves. • Use Arbor Day to educate and support ongoing urban forestry efforts.
Individuals	• Plant native trees and allow "volunteers" to grow in place when possible. • Include high canopy, understory and low-growing trees and vegetation. • Support your community's urban forest and street tree maintenance and planting program when your city budget is being passed.

CONSERVE CRITICAL SOILS

Keeping soils permeable allows infiltration and groundwater recharge

KEY BENEFITS of Conserving Critical Soils include:

- Allowing stormwater to infiltrate into the ground
- Filtering and cleaning groundwater and recharging aquifers that supply wells

CRITICAL SOILS are those soils that allow water to infiltrate (well-drained soils) and those that absorb and hold water before releasing it into the water table. They include the topsoil that is so often removed and not replaced during construction.

These soils are most often found in wooded or naturally vegetated areas, so when protecting these areas you are also protecting critical soils. They should be incorporated into conservation areas of building sites, and protected from damage or compaction during construction. Once these soils are removed by construction grading, or compacted by construction equipment, their function is forever lost to the watershed.

KEY ROLES	KEY ACTIONS
Administration, Economic Development, Community Development	• Account for the value of drainage services that permeable soils provide in storm water management. It is the inverse of the damage that impervious surfaces cause. • Discourage development on high quality permeable soils. Instead, encourage development on soils that are not as valuable. • Work with private landowners to establish conservation areas where valuable draining soils exist.
Legislators, Planning Commissions	• Require that critical draining soils be protected from compaction or removal during construction. • Encourage landowners to keep grassy swales maintained with native vegetation. • Amend mowing laws to allow taller grasses and native vegetation.
Service, Engineering	• Place compaction limitations on disturbed areas of critical soils. • Retain natural drainage patterns whenever possible. • Use infiltration tables that account for post-construction compaction.
Developers	• Avoid building on well-drained soils. • Avoid compaction during construction. • Replace topsoil after construction to the level before construction, and plant with native species, not turf grass.

CONSERVE STEEP SLOPES

Keeping the land on the land keeps the waters healthy

KEY BENEFITS of Conserving Steep Slopes

- Keeping steep slopes vegetated and stable reduces erosion
- Reducing erosion reduces sediment loads, which reduces flooding

Minimizing disturbance of these steep hillsides means avoiding them when siting development, or planning access roads to development. Existing vegetation should be preserved, since its presence proves that it is acclimated to the area and is a functioning part of the landscape. Replacing native cover with decorative cover can have disastrous results and can actually increase erosion.

KEY ROLES	KEY ACTIONS
Administration, Economic Development, Community Development	• Discourage development on or near steep slopes. • Work with landowners to establish conservation areas where steep slopes exist. • Invest in restoration where development may already be negatively impacting soils and degrading slopes.
Legislators, Planning Commissions	• Expand riparian setbacks based on site-specific conditions, especially where slopes are greater than 10% and are within 500 feet of a watercourse. • Require special permitting to limit development and disturbances in areas with slopes greater than 15%.
Zoning Appeals Boards	• Disallow variances that encroach on setbacks from steep slopes. • Do not allow replacement of vegetation around steep slopes with impervious surfaces, including turf grass.
Developers	• Design sites to avoid building near steep slopes. Structural solutions may be short term remedies, but soils erode. Period. • Avoid disturbing steep slopes during construction. Construction equipment will change soil character and compaction. • Replace any disturbed soils with native vegetation, preferably those with large and/or dense root systems.

ZONE FOR CONSERVATION

KEY BENEFITS of Conservation Development

- Preserves a community's open space inventory at no cost to the community
- Conserves large natural areas for flood plain, riparian corridors, wetlands and habitat to insure and improve watershed functions
- Allows development of open space networks when contiguous areas are linked

Land use planning and zoning codes are powerful tools we've used for decades to design how our communities function and set reasonable restrictions that allow different uses to coexist.

Natural infrastructure functions for stream health are land uses, and should be included in zoning codes.

CONSERVATION DEVELOPMENTS use the clustering of buildings to reduce construction costs and increase allowable densities on a development site, leaving significant portions of the land as natural areas.

Some communities already use PUDs (Planned Unit Developments) or PURDs (Planed Unit Residential Developments) to give a developer a "density bonus" to increase the number of units on a site by clustering units rather than spreading them out across the project area, as is the case with traditional subdevelopments where each home or building has its own lot. This does tend to leave more contiguous greenspace areas, but they are often covered in turf grass and are designed more with economy in mind than conservation.

Conservation development goes a step further, in that it conserves or improves the community's inventory of natural resources by requiring that 35-40% or more of the site be set aside, permanently, for open space and natural areas. Communities that honor riparian setbacks will see that those set-asides can easily be incorporated into the conservation areas.

ZONE FOR CONSERVATION

KEY ROLES	KEY ACTIONS
Administration, Economic Development, Community Development	• Encourage establishment of conservation development zoning. • Encourage builders and developers to include conservation easements in projects that do not fall into conservation zoning areas. Promote the benefits of setting aside large areas of land, especially when they connect or connect to other natural areas. • Include 'green living' as a community asset. • Provide incentives for developers who use the conservation option.
Legislators, Planning Commissions	• Establish Conservation Developments in the zoning code. • Identify preferred conservation development areas in your master plan (separate from conservation areas where all lands are left natural.)
Zoning Appeals Boards	• Do not allow variances that would reduce the total amount of natural areas, nor ones that would allow breaking up of natural areas. These lands must remain large, contiguous portions of the site. • Do not allow variances that would reduce any dimension of an area to be less than an existing setback, for example, a 75-foot riparian setback.
Developers	• Choose conservation development for the site, and include LIDs (Low Impact Designs) in the design of clusters and individual units.
Stewardship Groups	• Support adoption of conservation development. • When zoning is adopted, educate adjacent landowners about conservation easements and explain how connecting their natural areas or riparian zones to others can reap benefits for the stream and watershed.

{ Think About This:

LIDs play a major role in creating green jobs for the future. Rain barrels will not be round, recycled drums for long.

Communities that support entrepreneurs who design, manufacture and install state-of-the-art systems, designed to blend in with the homes or commercial buildings they serve, will win two ways: Their properties will rise in value and their income tax receipts will rise as well. }

ADOPT LOW IMPACT DESIGN FEATURES

Managing stormwater at the source, one property at a time

KEY BENEFITS of Low Impact Development & Design

- Storing, filtering and managing stormwater at the source
- Reducing flooding downstream
- Spreading the cost of stormwater management among more properties
- Reducing the need for expensive, extensive structural control and treatment
- Restoring some of the original function of a property in the larger watershed system

LOW IMPACT DEVELOPMENT is an approach to site design that mimics natural processes by using small scale, decentralized features that infiltrate, evaporate, detain and transpire stormwater.

These stormwater controls are strategically located throughout the site, and are designed to minimize runoff, restore pre-development flow patterns and processing times, and disperse storage and runoff throughout the site.

Key LID practices and features are primarily low cost and low-tech, and include:

- reducing impervious cover overall,
- using pervious paving when necessary
- minimizing disturbance of soils and vegetation
- using riparian and wetland setbacks
- preserving and recreating natural landscape features with native plantings
- increasing disconnection from structural water management systems using rainbarrels, rain gardens, cisterns, etc
- facilitating infiltration and detention with bioswales and infiltration strips.

{ A property could use a variety of methods to reduce flow offsite virtually to zero:

- Extensive plantings, including multi-story forest cover and naturalized areas absorb and store precipitation and riparian areas block runoff into streams.
- All paving would be permeable - gravel, pavers, or permeable concrete or asphalt.
- Green Roof plantings would absorb precipitation and snowmelt.
- Excess roof runoff would flow through gutters and downspouts to storage facilities - rain barrels for short-term small amounts or cisterns for larger, longer-term storage.
- Additional runoff would be directed to naturalized retention areas such as rain gardens, bioswales and infiltration trenches or ponds - with naturalized native plantings to absorb and transpire water or allow it to evaporate from the surface. }

ADOPT LOW IMPACT DESIGN FEATURES

Low Impact Development Design features can be retrofitted to existing properties or designed into new construction. In either case, the more widespread the practice the better, for individual landowners and especially for the community as a whole.

The primary role of the local government is to remove obstacles in building and housing codes so as to allow landowners to implement these strategies.

KEY ROLES	KEY ACTIONS
Administration, Economic Development, Community Development	• Encourage residents and businesses to retrofit properties with LID elements, and support code changes if necessary. • Incentivize installation of LID practices on existing properties; recognize the stormwater management value and contribution to reduction of cost and burden on municipal systems. • Reward developers who use LID practices and reduce your stormwater infrastructure costs.
Legislators, Planning Commissions	• Allow for implementation of LID techniques in building codes. • Adopt LID provisions in zoning of residential, commercial and industrial districts. • Set maximum parking lot size rather than minimum. Size for average demand rather than peak demand. • Limit area of impervious surface allowed, including roofs and impervious paving, as percentage of total area.
Zoning Appeals Boards	• Allow variances for LID techniques, especially those where adjoining property owners wish to collaborate on shared features.
Service, Engineering	• Provide assistance for property owners in installing and maintaining features where appropriate.

ADOPT LOW IMPACT DESIGN FEATURES

LOW IMPACT DEVELOPMENT is one area where the efforts of individuals and organized watershed groups could have the greatest impact on stormwater management and pollution prevention.

Many of the features are perfect for do-it-yourselfers or for group projects. Results can be measured and goals can be set. Installing features provides education opportunities as well.

KEY ROLES	KEY ACTIONS
Developers	• Leave ample forest or plant generously, especially in riparian areas. • Incorporate LID features in site design. • Use more, smaller distributed retention and filtration features rather than one "big hole". • Reduce soil compaction and replace topsoil after construction. • Landscape with native plants.
Stewardship Groups	• Educate property owners, builders, developers, home improvement professionals and do-it-yourselfers about LIDs. • Work with local businesses to sell and train people how to install and use rainbarrels, cisterns, etc. • Present installation and maintenance of LIDs as workforce training and job creation tools. • Offer workshops on rainbarrels and raingardens, green roofs and organic landscapes and gardening. • Take the lead in reforesting private lands.

GO NATIVE

Replace invasive and non-native plants with native species

KEY BENEFITS of Using Native Plants

- Reducing the need for irrigation
- Reducing or eliminating the need for additional fertilizer or pesticide use
- Providing habitat for native wildlife that can manage pests naturally

Invasive exotic species are overtaking our lands, especially along streams where normally would be the most diverse flora and fauna. When exotic species invade they crowd out the native plants that provide food and shelter to native animals, so they put entire life systems at risk. Native animals control native pests. Remove the habitat, and you remove the native pest control.

Native plants are those that have been present in an area since before human settlement. They are adapted to a place and serve a function as part of a web of life especially suited to the climate, soils, weather and wildlife of that place. As such they require less fertilization and no irrigation.

KEY ROLES	KEY ACTIONS
Administration, Economic Development, Community Development	• Use public property to showcase native species
Legislators, Planning Commissions	• Prohibit the planting on public property of invasive exotics
Service Departments	• Assist local nurseries by spending your landscaping funds with them if they promise to grow native plants for city plantings
Stewardship Groups	• Educate landowners about native plants • Use a native plant sale to raise funds and awareness

MANAGE YOUR MANURE

What happens on the land doesn't always stay on the land

KEY BENEFITS of Controlling Nutrient Runoff

- Reducing algae growth and resultant oxygen depletion, especially in primary headwater streams often found in rural areas
- Reducing bacterial pollution that keeps waters "unswimmable"

Nutrients, ammonia and bacteria that come from unprocessed human and animal waste as concentrated additions to the watershed environment will overload the system's ability to process waste.

Regular maintenance of septic systems is one of the most important things a property owner can do to improve the water quality of a watershed.

Keeping livestock away from streams and not dumping yard waste are also important strategies.

KEY ROLES	KEY ACTIONS
Administration, Economic Development, Community Development	• Incentivize use of current best technologies for private waste treatment situations. • Work toward development of municipal treatment services.
Legislators, Planning Commissions	• Require larger riparian setbacks in areas where septic systems are used. • Institute anti-dumping ordinances that prohibit dumping of all yard waste and animal waste into streams.
Service Departments	• Monitor streams for dumping violators. • Enforce health regulations concerning septic system maintenance. [a] Monitor the activities of manure service companies.
Stewardship Groups	• Educate landowners about nutrient and manure problems in streams.

Additional Resources
Know More

Now that you know a little about watersheds and streams, and community planning for their health and well-being, you're bound to want to know more.

The organizations, programs and links listed here are ones we think will help you along the way. It's not a complete list, but it's a starting point.

Don't forget, the best resource to teach you about your watershed is just that... your streams and your rivers and the natural habitat that supports you.

Ohio Lake Erie Commission	http://lakeerie.ohio.gov
Ohio EPA	http://www.epa.state.oh.us/
Ohio Department of Natural Resources	www.dnr.state.oh.us/
U.S.EPA	http://www.epa.gov/
Ohio Environmental Coalition and Northeast Ohio Watershed Council	http://www.theoec.org

Community Stewardship
Do More

Now that you know what's at stake for your community and the region, and you know more about how to restore and take care of the system, we hope you'll want to do more.

Personal Stewardship

Any serious change starts with individuals. If you're reading this book and you've made it this far, chances are you're already doing some of the things that will help your watershed. Whether you're a community official or a resident, your own behavior teaches your neighbors what you value.

You can start with putting Low Impact Design features at your own home or place of business. If that's not an option, how about promoting the practice at businesses you frequent or at your workplace?

Be a model, or an advocate, or both.

Community Stewardship – Watershed Groups

One person really can make a difference. But it's usually easier and often more effective to work with a group.

If your community has a watershed council, join it. If it's a council of governments and not a watershed stewardship group, go to their meetings. If there's no stewardship group in place, create one. If there's a group, join it!

In our Cuyahoga River watershed, with almost twenty major tributaries with their own subwatersheds, there are many groups that have grown quite effective, starting out as a bunch of volunteers pulling shopping carts and litter out of creeks or yanking invasive garlic mustard out of streambanks. This is where change really happens. These are the folks that teach their neighbors and involve their schools and bring the community together in support of their treasured natural areas.

All it takes is a few people willing to get together to do a project...a "welcome to our watershed" brochure, a "creek day" or a "read about watersheds" day at the library. If you need help, call on the nearest park system or the local science teacher, or the garden club. Just start somewhere!

10 Habits for Healthy Watersheds

for cities, villages, and townships

1. Create an official partnership with the communities who share your watershed. Include your planning commission, engineer and some citizens. Do something.

2. Adopt a Watershed Management Plan and add a map of Preferred Development Areas and Preferred Conservation Areas to your Master Plan. Create Conservation Development zoning. Balance Growth and Stewardship.

3. Commit to a set of best practices that all the communities in the watershed will act on, even if it starts out small, with stopping mowing to the edge of streams and planting native species along riparian corridors. Be the change you want to see.

4. Identify the sensitive areas in your watershed and conserve them - buying the land might be less expensive in the long run than the cost of replacing those stormwater management services with structural solutions. Think long-term.

5. Support citizens and property owners or managers who want to use Low Impact Design features for stormwater management, and remove any obstacles in your codes (like requiring concrete or asphalt rather than allowing gravel or permeable paving for driveways, parking lots and walkways.)

6. Reduce impervious surfaces! Use maximum number of parking spaces for site requirements rather than minimums. (No, that's not a typo.) Unpave vacant and abandoned parking lots and driveways that are disintegrating. Unpave your community.

7. Pass whatever laws you need to pass to protect streams. Get your riparian setbacks in the code, and your erosion prevention programs in place, and then enforce them. Enforce anti-dumping laws. Get serious.

8. Get your service department workers, and whoever else needs it, trained in watershed stewardship so they know and can explain to others the reasons for their new policies and practices.

9. Put a raingarden at city hall, host rainbarrel workshops, put up signs where you've planted native meadows to show your citizens that you are stewards, and help build a citizen's stewardship group. Be the champion.

10. Reward citizens who do good things – green building, LIDs, native planting, creek cleanups, education programs.

And go to the stream or river or wetland in your watershed and look at it, in different seasons, to remind yourself why you love where you live.

for citizens, property owners

1. Adopt watershed-friendly behaviors. Plant natives, don't overfertilize or mow to the edge of a watercourse, mow high and let clippings lie, compost your leaves, put in a rain garden, rain barrels, etc.

2. Support the local officials who support stream stewardship.

3. Join or form a watershed stewardship group, learn about your watershed, host activities like cleanups and invasive plant pulls, do education projects, be the voice of the stream when it needs defending.

4. If you have riparian land, keep it vegetated. Consider a conservation easement that would keep the land natural forever.

5. Be an ambassador for stewardship wherever you go. Ask your garden center to sell native plants and soil test kits, and to host rain garden workshops.

6. Make your property a showcase for permeable paving and then show it off.

7. Minimize storm water runoff from your property. Wash your car on lawn so the soap doesn't run into the storm drain.

8. Don't flush leftover prescription drugs down the toilet or drain.

9. If you have a septic system, maintain it. If you have a pet, bag the waste.

10. Keep soil from eroding into storm drains or into creeks and streams.

And go to the stream or river or wetland in your watershed and look at it, in different seasons, to remind yourself why you love where you live.

Add your ideas and plans here:

Speaking the Language
Acronyms & Glossary of Terms

Whether you get involved in stream and watershed stewardship as a local official or as a resident, you will hear terms with which you may not be familiar.

The language of any profession should not be a barrier to communication, so we have included a section of translations and definitions that can put you at least on the same planet as the professionals if not exactly on the same page.

Understanding the Lingo • Acronyms

Every profession has a language, and practitioners often adopt acronyms to speed up their conversations. Here are some of the common ones used in the business of watersheds and water quality.

ACRONYM	STANDS FOR...	DEFINITION
AHR	American Heritage River	A federal initiative designating 14 American Heritage Rivers having significant and unique roles in our country's history.
AOC	Area of Concern	Areas identified by the IJC as having pollution levels that pose existing or potential threats to the health of the Great Lakes
BGI	Balanced Growth Initative	A strategy to protect and restore Lake Erie and its watersheds to assure long-term economic competitiveness, ecological health and quality of life.
BMP	Best Management Practice	Management or structural practices designed to reduce the quantities of pollutants washed off the land and into waterways.
BUI	Beneficial Use Impairment	A condition where the chemical, physical, or biological integrity of a water system is unable to meet various quality levels or provide support for aquatic life. 14 BUIs comprise the "List" that a Great Lakes Area of Concern must remove or remedy in order to reach its goal.
COE	Army Corps of Engineers	The department with control over the structure and operations of U.S. navigable waters
CREP	Conservation Resource Enhancement Program	A voluntary land retirement program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. It is administered by USDA's Farm Service Agency (FSA).
CRP	Conservation Reserve Program	A voluntary program for agricultural landowners to receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland.

ACRONYM	STANDS FOR…	DEFINITION
CSO	Combined Sewer Overflow	The location where storm water and municipal wastes are discharged untreated to streams, in systems where sewers convey both sanitary wastes and storm water runoff in the same pipe, and on occasions when heavy rain creates increased flow that overloads the capacity of the waste water treatment plant
CWA	Clean Water Act	Also known as Public Law 92-500, "Federal Water Pollution Control Act Amendments of 1972", the Act establishing a goal of fishable and swimmable waters (by 1983) and elimination of pollutant discharges into navigable waters (by 1985). Amended in 1977, 1981 and 1987.
CWH	Cold Water Habitat (fauna)	Waters capable of supporting populations of native coldwater fish and associated vertebrate and invertebrate organisms and plants on an annual basis.
DNAP	Division of Natural Areas and Preserves (ODNR)	The part of the Ohio Dept. of Natural Resources dealing with natural areas, parks and preserves
EQIP	Environmental Quality Incentives Program	Part of the Farm Security and Rural Investment Act of 2002 (Farm Bill) providing financial and technical help to assist eligible participants to install or implement structural and management practices on eligible agricultural land.
EWWH	Exceptional Warmwater Habitat	Waters capable of supporting and maintaining an exceptional or unusual community of warmwater aquatic organisms
FMF	Forest Mitigation Fund	AKA "Tree Mitigation Fund", a fund set up to receive monies paid in lieu of mitigation, in cases where trees are cut or forest is cleared for construction. If forest is not replaced, restored or enhanced on private property by the developer, monies can be deposited into the Fund for use either to carry out mitigation on private property or to plant and maintain urban forests on public land.
FWS	Fish and Wildlife Service	A division of the U.S. Department of the Interior

ACRONYM	STANDS FOR…	DEFINITION
GIS	Geographic Information System	A method for imaging land areas using latitude and longitude and satellite information to place and map various landforms and features.
GLC	Great Lakes Commission	The binational agency that promotes the orderly, integrated and comprehensive development, use and conservation of the water and related natural resources of the Great Lakes basin and St. Lawrence River. Its members include the eight Great Lakes states with associate member status for the Canadian provinces of Ontario and Québec. The Commission was established by joint legislative action of the Great Lakes states in 1955 (the Great Lakes Basin Compact) and granted congressional consent in 1968.
GLNPO	Great Lakes National Program Office (USEPA)	The part of the US Environmental Protection Agency that oversees and helps Great Lakes stakeholders work together in an integrated, ecosystem approach to protect, maintain, and restore the chemical, biological, and physical integrity of the Great Lakes.
GLPF	Great Lakes Protection Fund	A private, nonprofit corporation formed in 1989 by the Governors of the Great Lakes States. It is a permanent environmental endowment that supports collaborative actions to improve the health of the Great Lakes ecosystem.
IBI	Index of Biological Integrity	Used to measure the ability of a set of elements in a given biological system to function in the current environment as compared to how the same set would function in the absence of human effect on the environment.
IJC	International Joint Commission	The bi-national governmental body tasked with preserving, protecting and restoring the health of the Great Lakes
LEPF	Lake Erie Protection Fund	Provides grants for programs and projects that protect or restore Lake Erie and its watershed in Ohio

ACRONYM	STANDS FOR…	DEFINITION
LID	Low Impact Design/Development	Design or development strategies or structures that reduce surface runoff of storm water and pollutants or improve water quality exiting a site.
MS4	Municipal Separate Storm Sewer System	A drainage system for conveying stormwater, sewage and other wastes, which is NOT a combined sewer system
MWH	Modified Warmwater Habitat	Waters found to be incapable of supporting and maintaining a balanced, integrated, adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat.
NPDES	National Pollutant Discharge Elimination System	The permitting system established by the Clean Water Act that imposes limitations and monitoring requirements for point-source discharges from municipal, private or industrial sources.
NPDES Phase II		The permitting rules created by USEPA requiring municipalities in urban areas with separated storm sewers to control polluted runoff from nonpoint sources
NPS	Nonpoint Source (pollution)	Pollutants (fertilizers, pesticides, road salt, automotive waste and others) that wash off surfaces and into waterways and are not attributable to a single source.
NRCS	Natural Resources Conservation Service	A service of the USDA to help non-federal landowners conserve soil, water and natural resources.
ODNR	Ohio Department of Natural Resources	The department charged with managing the state's land and water resources
OEEF	Ohio Environmental Education Fund (OEEF)	The Ohio EPA Office of Environmental Education administers the Ohio Environmental Education Fund (OEEF), which awards grants for education projects to enhance the public's awareness and understanding of issues affecting environmental quality in Ohio.

ACRONYM	STANDS FOR…	DEFINITION
OEPA	Ohio Environmental Protection Agency	The state agency responsible for protecting the environment and public health by ensuring compliance with environmental laws.
OLEC	Ohio Lake Erie Commission	A collaboration of 6 state agencies working to improve Lake Erie. Supports the LEPF.
ORAM	Ohio Rapid Assessment Method (for Wetlands)	Method of categorizing wetlands based on quality
OWDA	Ohio Water Development Authority	The state agency that provides loans and technical support for environmental infrastructure projects
QHEI	Qualitative Habitat Evaluation Index	A method for evaluating stream habitat quality.
PCA	Preferred Conservation Area	In Balanced Growth Watershed Planning, an area designated for conservation to preserve natural functions
PDA	Preferred Development Area	In Balanced Growth Watershed Planning, an area where development would have the least negative impact on watershed functions
PRA	Preferred Restoration Area	An area where critical watershed features could be restored to higher function and result in significant benefits to the watershed.
RAP	Remedial Action Plan	Refers to the plans, as well as the organizations managing them, that work to assess impairments and restore beneficial uses in designated Areas of Concern in the Great Lakes Basin
SWCD	Soil And Water Conservation District	County agency providing technical support to communities to protect and conserve soil, water and natural resources.

ACRONYM	STANDS FOR…	DEFINITION
TMDL	Total Maximum Daily Load	A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs. (USEPA)
TMF	Tree Mitigation Fund	See FMF, Forest Mitigation Fund
USDA	U.S. Department of Agriculture	
USEPA	U.S. Environmental Protection Agency	
USFS	U.S. Forest Service	
USFWS	U.S. Fish and Wildlife Service	
USGS	U. S. Geological Survey	
WRP	Wetland Reserve Program	A program of the NRCS providing financial support for wetland restoration and protection projects
WWH	Warm Water Habitat	Waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms

Understanding the Lingo • Glossary of Watershed Terms

Good communication is essential for making and carrying out decisions, plans and activities relating to watersheds and stormwater management. This glossary is a step toward helping non-professionals in conversation with the pros.

ALTERNATIVE SITE DESIGN	Innovative site design practices developed as alternatives to traditional development methods to control storm water pollution and protect the ecological integrity of developing watersheds, with emphasis on reducing impervious cover, runoff volume, pollutant loading and development and long-term maintenance costs.
BASEFLOW	The portion of streamflow that is not due to storm runoff but is the result of ground water discharge
BIORETENTION	A practice to manage and treat storm water runoff using a specially designed planting soil bed and planting materials to filter runoff stored in a shallow depression. Proper bioretention areas include a mix of elements, each designed to perform different functions in the removal of pollutants and attenuation of storm water runoff.
CHANNELIZATION	Alteration of a stream channel by widening, deepening, straightening or paving areas in order to speed flow.
CHECK DAMS	Small, usually temporary, dams constructed across a swale or drainage ditch to reduce the velocity of storm water flows.
CONSERVATION DEVELOPMENT	A land use plan, and often a zoning designation, for developments that preserve a significant percentage of land as open and/or natural space so as to preserve natural habitat, reduce erosion and protect water quality.
CONSERVATION EASEMENT	An agreement that transfers a landowner's rights to develop or consume a property to a public or private entity that agrees to conserve the land in perpetuity
CONSTRUCTION SITE EROSION AND SEDIMENT CONTROL PROGRAM	Policies adopted by local governments requiring developers to implement best management practices to prevent the erosion and transport of sediment to streams from development sites
CRITICAL FEATURES	Elements of a watershed system, such as wetlands, soils, slopes, riparian corridors, forest cover, that are essential components to the proper functioning of the natural water management system and to stream health
DELISTING	The goal of the work of the OEPA and RAPs, to restore beneficial use impairments (BUI) enough to remove an Area of Concern or a part thereof, from the IJC's list of waters that have negative impacts on the Great Lakes.

DETENTION	Managing storm water runoff by temporarily holding it and controlling its release.
DETENTION BASIN	Also called "Dry Detention Pond", a storm water basin designed to capture, temporarily hold, and gradually release a volume of storm water runoff in order to attenuate and delay peak runoff. They control storm water quantity and protect stream banks from erosion during peak events but do not affect water quality.
DIKE	An embankment to confine or control water
DRY WELL	A small excavated pit or trench filled with aggregate that receives storm water runoff, primarily from rooftops, and serves as an infiltration system to reduce the quantity of runoff from a site.
EPHEMERAL STREAM	A stream with flowing water only during, and for a short duration after, precipitation events in a typical year. Ephemeral streambeds are located above the water table year-round. Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow.
ENHANCEMENT	Activities conducted to improve or repair existing or natural functions and values of a stream or wetland.
FOREST COVER	Includes all the elements and layers of a healthy forest, including tree canopy, understory trees, shrubs and brush, ground cover and vegetation, decaying organic material (duff), and animal habitat.
FLOOD PLAIN	A watercourse and the areas adjoining it that periodically are covered by flood waters during heavy precipitation when streams overflow their banks
FUNCTION	The type of water quality service provided by the watershed feature or resource. This may include habitat for wildlife, flood control, filtering, erosion control, etc.
HYDRIC SOILS	A soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Reduced oxygen pathways limit the ability of most plants and microorganisms to thrive.

IMPERVIOUS	Not allowing water, air or light to pass through.
INTERMITTENT STREAM	A stream or portion of a stream that flows only in direct response to precipitation, and is dry for a large part of the year.
MITIGATION	The restoration, creation, enhancement, or preservation of a wetland or forest to make up for the loss of a wetland or forest that is destroyed by development.
MITIGATION BANK	An area or a collection of land areas where restoration, creation, enhancement, or preservation can take place so as to compensate for wetland and other aquatic resource losses in a manner that contributes to the long-term ecological functioning of the watershed within which the bank is to be located. Its purpose is to replace essential aquatic functions which are anticipated to be lost through authorized activities within the bank's service area, such as development or road-building.
MITIGATION FUND (FOREST)	AKA "Tree Mitigation Fund", a fund set up to receive monies paid in lieu of mitigation, in cases where trees are cut or forest is cleared for construction. If forest is not replaced, restored or enhanced on private property by the developer, monies can be deposited into the Fund for use either to carry out mitigation on private property or to plant and maintain urban forests on public land.
MITIGATION RATIO	The size of a mitigation site as compared to the original area that is being replaced, taking into consideration the relative level of service provided or lost.
OFF-SITE MITIGATION	Restoration, creation, enhancement, or preservation occurring outside a project boundary, but within the same watershed.
ON-SITE MITIGATION	Restoration, creation, enhancement, or preservation occurring within or adjacent to a project boundary.
NATIVE PLANTS	Plants that are adapted to local soil and rainfall conditions, require minimal watering, fertilizer and pesticide application, and provide food and/or shelter for native fauna.
NON-STRUCTURAL CONTROLS	Pollution control techniques, such as management actions and behavior modification, that do not involve the construction or installation of mechanical or structural devices.

PEAK DISCHARGE	The maximum instant flow from a storm event at a given location
PERMEABLE	Open to passage or penetration, especially by fluids
PERENNIAL STREAM	One that contains water throughout the year
PERVIOUS	Allowing passage through.
POROUS	Having pores through which light, air or water can pass
PRIMARY HEADWATER STREAM	A stream which has a watershed less than or equal to 1 sq. mile and a maximum pool depth less than or equal to 40 cm.
RIPARIAN CORRIDOR	An area along the banks of a river or stream that separates water bodies from developed land and is intended to protect the waterway and water quality from chemical and physical impact (pollution, erosion)
RIPARIAN/ WETLAND SETBACK	The areas along riparian corridors or wetlands, which are designated in local zoning codes, where limits are placed on structures and uses.
SECTION 319 NONPOINT SOURCE DEMONSTRATION GRANTS	Federal funds made available through OEPA/USEPA as a requirement of the Clean Water Act for nonpoint source pollution control projects.
STATE REVOLVING LOAN FUND	Low interest loans available for improvements to publicly owned wastewater treatment and conveyance facilities, some of which can support BMPs for control of nonpoint sources of pollution
WATERSHED STEWARDSHIP PROGRAMS & GROUPS	Community-based initiatives aimed at building involvement in support of stream monitoring, protection and/or restoration

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