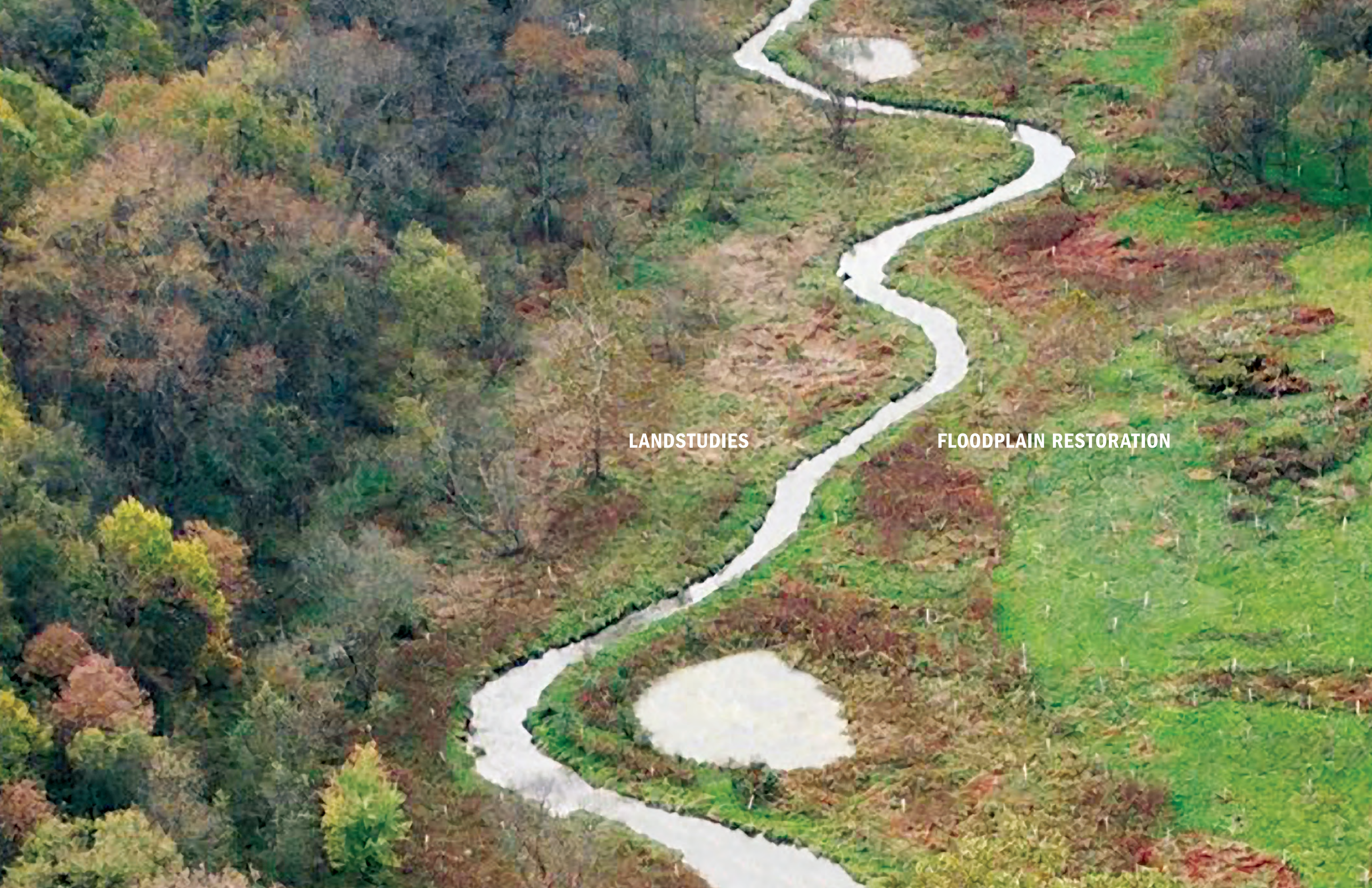

LANDSTUDIES
FLOODPLAIN RESTORATION

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INTRODUCTION

The following pages tell the story of stream systems – stream channels and their adjacent floodplains—in the Eastern United States, particularly in the region known as the Piedmont Province. You will learn how stream systems are supposed to work, what happened to our stream systems when we began to settle the East Coast, and why it is so important to restore them as much as possible to their original condition. You will learn about the numerous components in a stream system and how, when they are working in concert, the benefits are numerous and vital to our environment, our economy, our culture, and our communities.

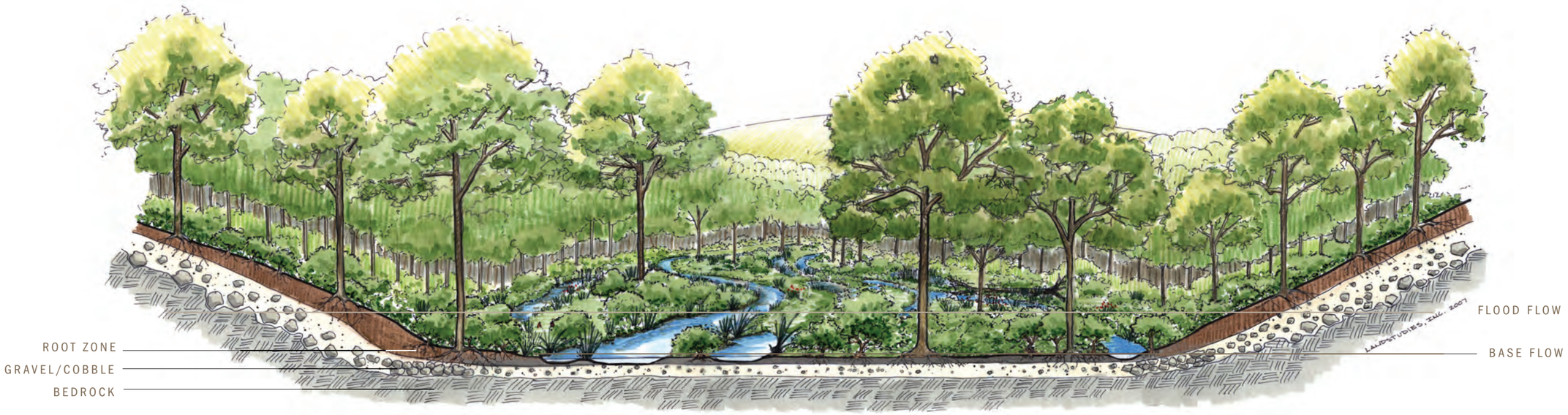
For some years we've known that all is not well with our rivers and streams, but until recently, we focused our efforts primarily on the water channels. Through the field work we've done and observations we've made at LandStudies, coupled with the invaluable research of our colleagues, Dr. Arthur Parola at the University of Louisville, and Drs. Dorothy Merritts and Robert Walter at Franklin and Marshall College in Lancaster, we now know that much of the work to repair our streams should first be focused on the floodplains and the "legacy sediments" that have filled them.

Floodplain restoration, as described and discussed in the following pages, is based on a restoration that puts the stream channel and floodplain at or very near their historical elevations and locations. What you will read in these pages is only the beginning of a complex, still-evolving tale. Our intent is to help you understand the basics of the story, the value and importance of floodplain restoration, and how properly restored stream systems can benefit you.

I believe that the human spirit is captivated and much of our human story captured in our river system, and I've seen intractable problems overcome when the narrow issues are broadened into everyone's connection to that body of water. There is a way in which those rivers and streams can call forth the better angels of our nature.

– KATHLEEN MCGINTY, SECRETARY, PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

HISTORICAL CONDITIONS



We're pretty sure that during the last few thousand years, the stream valley was probably a mixture of little pools that are linked together by small trickling streams with wet meadows behind them.

We know the floodplains were thin. We actually think the floodplains were not the result of single meandering channels but rather in many cases the anabranching stream where you have vegetated islands that are pretty resistant to erosion because they were organic-rich, and then little streams trickling around those vegetated islands, so it was multiple channels of flow around stable islands. You can almost see it happening out there in the reservoir behind Safe Harbor Dam where you get these little islands emerging.

– DOROTHY MERRITTS, PROFESSOR, GEOMORPHOLOGY, FRANKLIN AND MARSHALL COLLEGE

THE PAST

To understand what happened to our streams and adjacent floodplains, we need to go back to pre-settlement times, before the late 1600s. Stream systems along the eastern portion of what is now the United States looked quite different from the streams we know today. Water ran down out of the mountains, welled to the surface from underground springs and seeps, and flowed in “sheets” across slopes during rainfall and snow, just as it does today. A major difference is what happened to it when it arrived in the lowest elevations, where waters from throughout the watershed met and either evaporated, percolated down through the ground, or flowed downstream, eventually to the sea.

Drs. Dorothy Merritts and Robert Walter, geologists in the Earth and Environment Department at Franklin and Marshall College, have done extensive research, both in this part of the U.S. and abroad, to determine the historical nature of streams systems in low-lying valleys. Their work has even begun to give us clues into the nature of the historical plant communities along streams. What they have discovered is that stream valleys originally were more like swamps, or big sponges. Unlike the familiar single channel we see today, these valley stream systems contained numerous and interconnected rivulets and wetlands. The headwaters of Lititz Run in Lancaster County, Pa., are described as being, in the early 1700s, “marshes fed by several converging, underground streams that originated in the hills to the northwest of Lititz.”[1]

Channels were narrow, shallow, and winding. Water flowed over beds composed of cobbles and gravels. Sediment loads moving into the stream valleys carved the channels just to the extent of creating enough flow force to move those sediments through the system without disturbing the cobble and gravel streambed either through erosion or excessive deposition. This is how a stream operates when it is in a stable state. Changes did occur, as they do in all natural systems, but by and large those changes were gradual and nondestructive.



LITITZ RUN SITE
LANCASTER COUNTY, PA
Flooplain restoration

Riparian (streamside) wetlands flank and interact with the channel in this restored stream and floodplain.



MCLVANE RUN
CHESTER COUNTY, PA
Restored channel

1 Lititz Springs Park, http://www.lititzspringspark.org/lsphistory.html, 2005. Lititz Springs Park and Penny Lane Graphics.



Field studies revealed these porous, organic soils as part of the original floodplain. (Photo by Robert Walter)



High flows in this restored stream and floodplain become low-energy, non-damaging sheet flows.

Floodplains were only a foot or so above the surface of the flowing water. They were “attached” to the stream channel. Floodplains were, by and large, wetlands – inundated nearly every time it rained and kept wet much of the year because the soils were so close to groundwater stores. The soils in pre-settlement floodplains also were highly porous, composed of decaying and decayed organic material from trees, shrubs, and other plant life growing there. That porosity allowed surface water to percolate down into the ground, replenishing the groundwater. During heavy rainfall or substantial snow melt, the excess surface water no doubt turned the valley stream systems into broad, shallow, sheets of water flowing through the valley.



The existing stable conditions of this channel and attached, wet floodplain along Sands Creek in New York, are uncommon in the Mid-Atlantic.

An important key to this kind of stream system was that, when there was rainfall or snow melt, the stream channels were too small to contain much of that excess water, so it spilled out onto the floodplain. In doing so, much of the water's energy was dissipated, so that excess flows damaged little, if anything, along the stream valley. The water simply spread out across the stream valley and flowed at a relatively gentle pace down the valley to receiving waters.

Surface water, groundwater, cobbles and gravels, organic, bacteria-rich soils, wetlands, native plants, native aquatic and riparian wildlife – all were intimately connected to sustain a stream valley system that cleansed both surface and groundwater, replenished groundwater supplies, stored water from high flows and sustained viable native plant and animal populations.

The bacterial component is a relatively under-appreciated aspect of how floodplain systems affect water quality in streams. What's happening is bacteria are able to utilize nitrates in groundwater and in the soil as part of their metabolic process in anaerobic conditions.

As the bacteria utilize that nitrate, nitrogen gas is released to the atmosphere. They're taking nitrate that's in the surficial groundwater and moving it into the atmosphere. The process is a one-way export of nitrogen out of the system. That's why it's a key process that needs to be happening in stream systems.

— JOHN SHUMAN, WATER RESOURCES SCIENTIST.



LITITZ RUN | LANCASTER, PA

Restored flooplain

Riparian wetlands are an integral part of effective stream and floodplain restoration.

Historically, the floodplain system was well vegetated with plant species native to the region and adapted to wet conditions. These plants, both vegetation and roots, helped slow excess flow. Root systems in the shallow floodplains reached right down to the streambeds, holding stream bank soils in place even during high flows.

The material in the channels and banks was ideal for an aquatic food web, the soils in the wet floodplains allowed plentiful groundwater recharge, and the riparian plant life housed and nourished a wide variety of native wildlife. Wetland plants also absorbed nutrients such as phosphorus and nitrogen from the water and soils.

The saturated, anaerobic (oxygen-deprived) conditions of the floodplain sustained another community that we are only beginning to fully appreciate: a bacterial community that used nitrogen from the groundwater for metabolism, just as we use oxygen.

Plant and bacterial communities were valuable in cleansing and filtering both surface and groundwater.







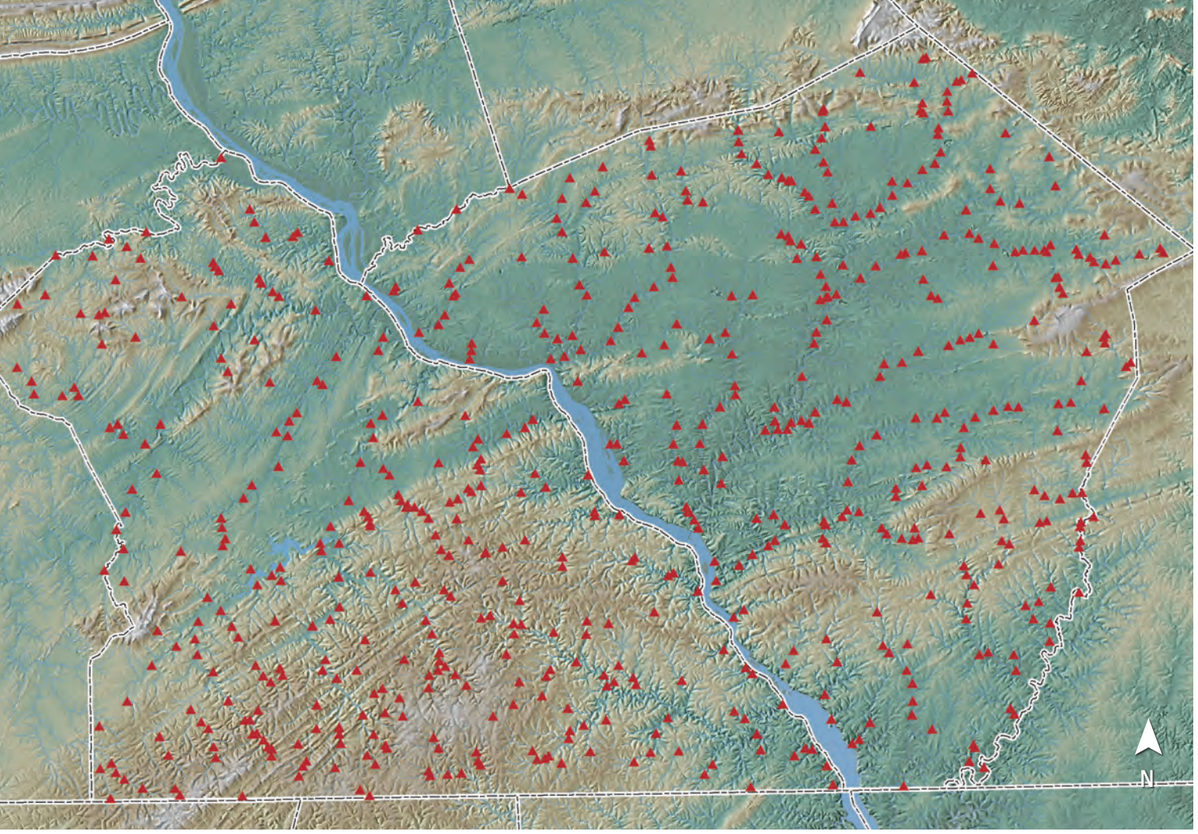
The profound damage caused by early, widespread logging and land clearing are evident in these old photographs.

SETTLEMENT

The story of floodplain restoration begins in the late 1600s, when Europeans first began to colonize our East Coast, establishing farms and towns and industries along the landscape's abundant rivers and streams. The story is one of human activity, and there were three important activities that took place concurrently over the years after settlement began – **timber harvesting, farming, and mill dam construction.**

Timber harvesting during settlement and exploration was done without regard for forest regeneration, because it seemed as though the forest went on forever. Consequently, hillsides were stripped bare and left to erode. Douglas MacNeal, in his book "A Penns Creek Companion,"[2] describes the deforested landscape of the ridge and valley section of Central Pennsylvania as "the Pennsylvania desert."

2 MacNeal, Douglas. 2005. A Penns Creek Companion. Penns Valley Conservation Association.



Distribution of historical mill dams in Lancaster and York Counties, Pa. Each red triangle represents one mill dam. (Graphic from a 2007 report to PA DEP, Estimating Volume, Nutrient Content, and Rates of Stream Bank Erosion of Legacy Sediment in the Piedmont and Valley and Ridge Physiographic Provinces, Southeastern and Central Pa.)

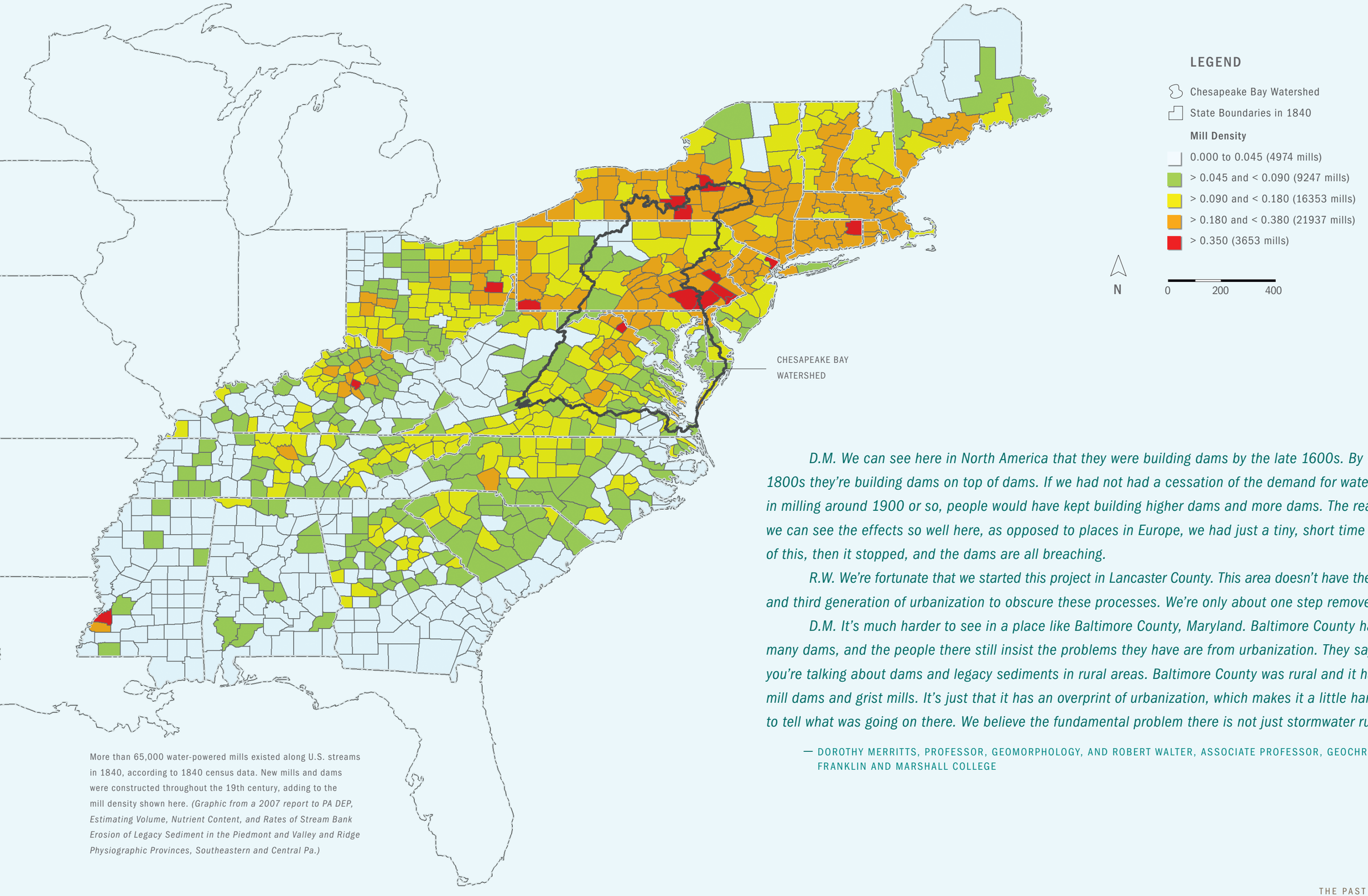
Among the more 'aha' moments for me in terms of the breadth and significance of legacy sediments was seeing Franklin and Marshall's maps identifying where there had been mills and other obstructions of streams and to see the relative number of dots on the maps compared to places where there were not dots. I had no idea that we had been such busy beavers throughout our history in Pennsylvania, effectively putting to work our waterways for our myriad projects and enterprises.

— KATHLEEN MCGINTY, SECRETARY, PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Eroded soils from the deforested hillsides eventually made their way into the lowlands – the stream and river valleys – where, had little else been going on, they probably would have washed downstream into places like the Chesapeake and Delaware Bays.

Farming, too, took its toll on the newly settled land. Farmers and settlers quickly cleared land in the gentle slopes and bottoms of the stream valleys, adding to the deforestation, and often created straight channels along the edges of the valleys to redirect the water into a single stream, leaving the nutrient rich valley soils open for farming. Plowing these fields contributed to the soil erosion affecting the streams, and both animal and human waste contributed to excessive nutrients such as phosphorous and nitrogen. Phosphorus usually attached itself to the eroding sediment particles. Nitrogen more commonly found its way into the groundwater.

But something else was going on. That "something else" was dam construction. The new settlers from Europe were skilled in establishing mills and employing water power to drive them, and they did so rapidly. Throughout the region, one mill after another sprang up on nearly every river and stream. Mill races – long straight channels constructed to direct and control water flow over the mill wheel – diverted water from established channels. Flowing water behind the dams was slowed, becoming more like ponds than streams. It wasn't long before the fine soils and sediments that were finding their way into stream valleys began to drop out in the ponded waters and build up behind the dams.



More than 65,000 water-powered mills existed along U.S. streams in 1840, according to 1840 census data. New mills and dams were constructed throughout the 19th century, adding to the mill density shown here. *(Graphic from a 2007 report to PA DEP, Estimating Volume, Nutrient Content, and Rates of Stream Bank Erosion of Legacy Sediment in the Piedmont and Valley and Ridge Physiographic Provinces, Southeastern and Central Pa.)*

D.M. We can see here in North America that they were building dams by the late 1600s. By the 1800s they're building dams on top of dams. If we had not had a cessation of the demand for water power in milling around 1900 or so, people would have kept building higher dams and more dams. The reason we can see the effects so well here, as opposed to places in Europe, we had just a tiny, short time period of this, then it stopped, and the dams are all breaching.

R.W. We're fortunate that we started this project in Lancaster County. This area doesn't have the second and third generation of urbanization to obscure these processes. We're only about one step removed.

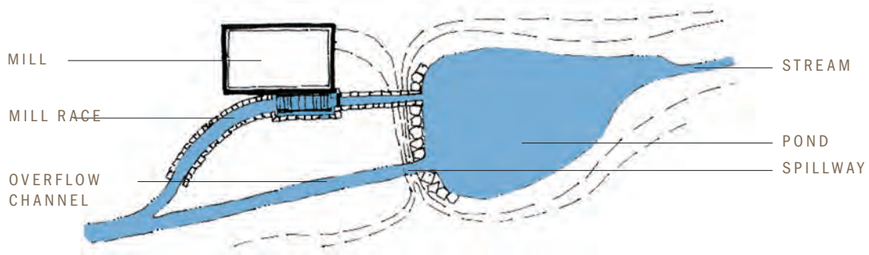
D.M. It's much harder to see in a place like Baltimore County, Maryland. Baltimore County had so many dams, and the people there still insist the problems they have are from urbanization. They say, well, you're talking about dams and legacy sediments in rural areas. Baltimore County was rural and it had mill dams and grist mills. It's just that it has an overprint of urbanization, which makes it a little harder to tell what was going on there. We believe the fundamental problem there is not just stormwater runoff.

— DOROTHY MERRITTS, PROFESSOR, GEOMORPHOLOGY, AND ROBERT WALTER, ASSOCIATE PROFESSOR, GEOCHRONOLOGY, FRANKLIN AND MARSHALL COLLEGE

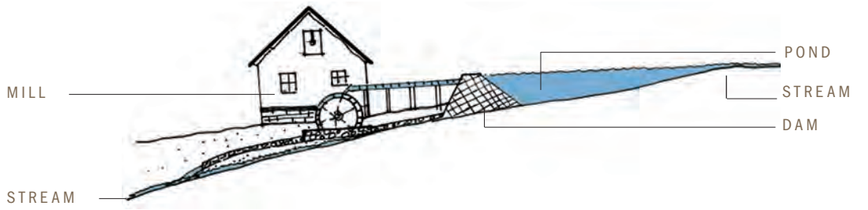


The high banks behind the former Denlinger Mill along the West Branch of the Little Conestoga in Lancaster County, Pa., show the lamina – the horizontal layers of sediment – which indicate that the sediments settled out in relatively still waters rather than accumulating from overland erosion. (Photo by Robert Walter)

PLAN VIEW



PROFILE VIEW



The drawing shows how water ponds behind a dam, allowing fine sediments to accumulate. (Adapted from Mills on the Tsatsawassa: Techniques for Documenting Early 19th Century Water-Power Industry in Rural New York, by Philip L. Lord, Purple Mountain Press, Fleischmanns, New York, 1983.)

Why do we have gravel in bars at higher elevations than in the banks? Why do stream systems that appear to have consistent bed loads and shallow depths appear to be the most stable? What is it that possibly made these floodplains so high compared with what appears to be a floodplain forming at a lower level now? All these things kept bothering me: What is going on that seems to be going on throughout the state? Then we started identifying the number of mill dams and mills associated with all the streams and the watersheds, and how the streams were tied to mill races. We are seeing how sediments in the flood-plain started looking like mill dam deposits and backwater deposits and not sediments that were formed by natural fluvial flows. You only had clays and fine sediments that were laminated and looked like old pond and dam deposits. Now we started to realize why these floodplains were created at the level they were created. It didn't have anything to do with a fluvial process depositing sediment at this level because that was the level needed for stability. The level of the floodplain happened to be the level of the dam, and the sediments were more related to the backwater effects of that dam than anything natural or fluvial.

— WARD OBERHOLTZER, P.E., WATER RESOURCES ENGINEER, LANDSTUDIES, INC.

You can picture what happened. As sediments built up in the ponded areas behind dams, both the channel bed and the floodplain rose. The channel bed, once gravel, now was sediment. The floodplain, once composed of highly porous organic matter, now was composed of fine sediments. Especially near the dams, much of the sediment consisted of impervious clay, through which water could not move downward easily. Surface flow no longer interacted with groundwater, which had remained where it was. Floodplain wetlands and vegetation were no longer connected to the groundwater, and the lack of cooling groundwater mixing with surface water caused stream water temperatures to rise. The historical channel bed and floodplain surfaces were buried under three to 20 feet of sediment. Channels became ponds, and often the dams were so close together along the stream that the ponded water from one dam extended upstream to the next dam. In many cases, streams became a string of ponds. Some of the many functions of the historical stream system had begun to be lost.



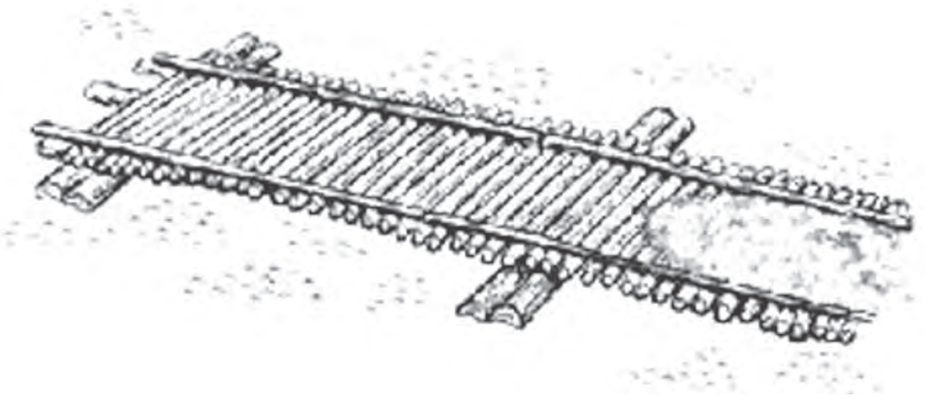
Deteriorating low-head dams such as this one in Montgomery County, Pa., contribute to stream system instability as ponded waters once again begin to flow and seek their historical locations and elevations.

Opportunities to improve our stream systems abound. Debris jams, remnant dams and headcuts (right) are common sights in our Mid-Atlantic stream systems. The man is standing in the streambed. The legacy sediments behind him are quickly eroding in an upstream direction, toward the sewer structure.



Fast forward to the 1950s. By this time, several circumstances affecting our stream systems had changed. Wholesale land clearing across the Piedmont and beyond had essentially ceased. Farm management had greatly improved. Human waste disposal was now largely controlled through municipal sewage waste systems. Water was no longer necessary for power. And industry was not forced to remain along streams. What all of these changes left in their wake was an elevated stream channel, an elevated floodplain, greatly diminished sediment loads coming into the stream valleys, abandoned mills, and crumbling dams.

Nature's next step is what we are witnessing today.



Corduroy roads were built from logs to provide a way to cross low or swampy areas. They decay slowly if they are buried in wet, acidic, anaerobic soils such as peat – the very kinds of soils that constituted historical floodplains. Above, a depiction of a corduroy road. Right, the remains of a streamside corduroy road buried under legacy sediments.



THE PRESENT

As dams deteriorated or were removed, water that had been ponded behind them began to flow again. In some cases, the old straight mill race became the main channel and the old stream channel filled in. And, of course, many streams had already been straightened when they were moved for farming.

This straightening is important, because a stream that meanders in gentle curves down through a valley is quite a bit longer than a stream that flows in a relatively straight line. When you shorten the length of a stream channel that still has to cover the same elevation change from the top to the bottom of the valley, you increase the slope, or steepness, of that channel, and that, in turn, increases the force with which the water flows.





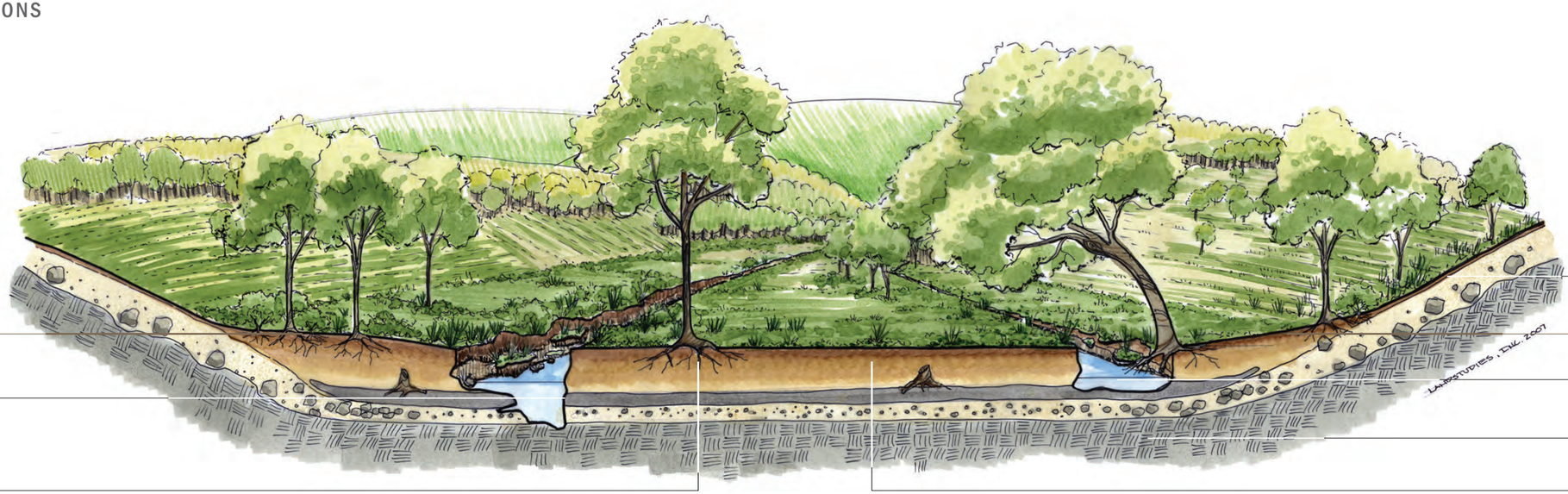


Channelized streams.

As the ponded water began to flow, its power and energy increased, and that allowed the flowing water to begin cutting down through the legacy sediments that had built up behind the dam. There was no similar force wearing down the adjacent floodplains, so they remained at their higher elevations. As the streams eroded downward toward their original elevations and cobble and gravel beds, the distance between the usual water surface (often referred to as “base flow”) and the top of the floodplain—which was now more accurately a terrace —became greater and greater.

The roots of the plants growing on the terrace could no longer reach down to the stream bed to help protect the banks, which often left many feet of exposed, bare soil along the banks. If you look at streams in your area, you will find many examples of this landscape.

CURRENT CONDITIONS



(A team of four students) went up the Little Conestoga, looking for areas of bank erosion and what might be causing it, and they made a turn up the West Branch. Within a very short distance they discovered this 20-foot-high wall of fine-grained sediment. Now they’d been seeing fine-grained high banks but more on the order of five to eight feet, not 20 feet. This is so spectacularly exposed, and has such beautiful fine laminae, they were really struck by it and took lots of pictures and came back and showed them to me.

I said there’s no way that’s overbank deposition—not 20 feet high. Right away we recognized that there’s a lot of floodplain that isn’t overbank sediment. It was hard to explain it as just post-settlement alluvium, because the idea is that the stream fills up, it aggrades, and then after the upland erosion ends it begins to subside. So I said right away, there has to be a dam there. I went out and found remnants of the dam instantly. I was struck by how far upstream the pond sediments went.

— DOROTHY MERRITTS, PROFESSOR, GEOMORPHOLOGY, FRANKLIN AND MARSHALL COLLEGE



This is the 20-foot high wall of legacy sediment along the West Branch of the Little Conestoga, behind the former Denlinger’s Mill in Lancaster County, Pa., that first caught the attention of researchers at Franklin and Marshall College. Here, too, as in the photo on page 10, the laminae are clearly evident. *(Photo by Robert Walter)*

I have a greater appreciation of legacy sediments than I did before. Most people doing watershed modeling have not considered stream bank erosion to the extent that it should be. Years ago, doing some work in the Philadelphia area, I realized that this is an issue that was not being addressed. So we built a stream bank erosion routine in our modeling system to account for that.

The issue of legacy sediments behind check dams is another factor that contributes to stream bank erosion. It's not the only factor, but this is another factor that probably should be considered and which our model does not consider directly—for example, the number of historical dams that may have existed in an area. No model does.

I agree that it matters, but I've not seen the kind of excessively high measurements that other people have reported seeing. I hear claims about the excessive volume that's moving, and I ask why that isn't showing up in the USGS stations. Well, because it happens in short periods over short stretches.

That may be true but I'm interested in modeling at the watershed level. There may be terrible spots in there where you have tremendous amounts of movement, but at the outlet you might not see that. But I'll admit, I don't know.

– BARRY EVANS, SENIOR RESEARCH ASSOCIATE, PENN STATE INSTITUTE OF THE ENVIRONMENTS



In this section of a Lancaster County, Pa., stream, the water has eroded down through legacy sediments and the historical floodplain to the original cobble bed. Lateral (sideways) erosion in the less resistant cobbles will eventually wear away the stream bank. (Photo by Robert Walter)

The evolution of a stream toward its former, stable configuration is a highly erosive process. It cuts downward, which is called incising, and erodes the sediments upon which it is sitting. That makes the channel deep enough to hold much more water than it did when the surface of the water and the surface of the floodplain were much closer together. More water means more energy, more force, more power to erode. And when the power of flowing water increases, it not only erodes the bed, it also erodes the unprotected, bare soil banks.



Undercutting due to lateral erosion is visible at the base of the bank.

Remember that these banks are now composed of the sediments that eroded down into the valleys many years ago. Also remember that these sediment particles are rich in phosphorus. When we have heavy rain or sudden snow melt, the force of the flowing water, unable to reach the high terrace, takes with it tons of sediment and pounds of phosphorus through the erosion of the channel bed and banks, depositing the eroded material in various locations downstream.

Something else happens. The stream also begins to erode sideways, which is called lateral erosion. This phenomenon is especially prevalent when the stream has eroded far enough down to hit the old gravels and cobbles. Because there is now so much more water in the channel than there was historically, and therefore so much more force, the gravels and cobbles are easily eroded away, the stream starts chewing away at the bedrock bottom, and it also begins eroding away the bottom of the sediment stack along the banks.

Perhaps you have seen portions of stream banks that have collapsed into the stream channel. These sections collapsed because of lateral erosion. We've all seen large trees with their roots exposed along the stream bank, leaning in toward the stream, and eventually falling into or across the stream. That, too, is the result of lateral erosion. Stream channels that were moved to the sides of stream valleys, where the elevation is a bit higher, also go through lateral erosion as they move back toward the middle of the valley, where the elevation is lowest.



Lateral erosion has undercut the stream bank, causing bank collapse along the Little Lehigh River in Lehigh County, Pa.

(The Lehigh Country Club) was having lateral movement of the stream channel. It was getting wider. We told them it's getting wider because the stream is incising and can't get access to the floodplain, so the erosive velocities are staying in the stream channel when they should be diffused out onto the floodplain. We're going to lower the floodplain and get those flows out much quicker. It's going to flood more frequently, but when it recedes you're going to have a more stable stream reach because it's not going to have that erosive velocity.

I think that is a classic scenario of how the Wildlands Conservancy came in and educated some really smart folks about another way to handle the problems associated with flooding and erosion and an unstable stream channel. And we also talked about how it was going to protect their infrastructure —tee boxes, greens, bridges. Some of these folks aren't doing it because they want to help the environment. They're not anti-environment, but they're doing it because it's going to save them money and protect infrastructure.

– CHRISTOPHER KOCHER, PRESIDENT, WILDLANDS CONSERVANCY

It can cost $45,000 to $60,000 to rebuild a green... $5,000 to rebuild a bunker. Before we considered floodplain restoration, we were looking at $25,000 to stabilize just one tee with a stone wall. Those things had the potential to be damaged. But now that we have the floodplain restoration, damage is minimized when we have floods, and cleanup is not nearly what it used to be.

Just to see how the stream is functioning now – it seems to be taking its natural course. When the water does get high it flows out nicely and comes back in quickly. We are really, really pleased with it. Things dry out quicker. I feel as though we've gained a couple days after these events. Obviously, that's something the golfers can really appreciate.

It's really a win-win for a golf course with water features or a stream corridor through their property. At some point in time they really need to look seriously at doing something like this.

– JOHN CHASSARD, DIRECTOR OF GROUNDS, LEHIGH COUNTRY CLUB



BEFORE: **SAUCON CREEK** | SAUCON VALLEY COUNTRY CLUB

What is going on in all cases is that the stream is trying to move back toward its original configuration, moving downward toward its original elevation, eroding away the artificially high terraces to create new floodplains, moving toward the lowest elevations in the landscape, and increasing its length through the creation of meander bends. In other words, the stream is moving back toward a stable state.

In the process, though, there often is damage to our now-occupied and heavily used valley lands and to our infrastructure, such as roads, bridges, and utilities. The process also contributes to the problems of heavily silted water, diminished native wildlife, inappropriate flooding, and imperiled groundwater supplies.

The current instability of most of the stream systems in our region, which really got under way in the middle of the 20th century, is now being recognized as a major contributor of sediment and nutrient pollution to our downstream estuaries and bays.



AFTER: **SAUCON CREEK** | SAUCON VALLEY COUNTRY CLUB | Floodplain restoration

LandStudies' approach to floodplain restoration speeds up the process of an unstable stream system working its way back toward stability, and it helps eliminate much of the damage that can occur to our now-occupied land and our infrastructure in the process.

Historical research and keen-eyed field observation help us determine where the stream channel most likely flowed before human intervention changed the landscape. Trenches dug down through the existing terraces show us how deep the sediments are and the depth to the original gravel bed and floodplain. Extensive field research helps us understand the upstream sediment load that will, over the long term, need to move through the restoration site without eroding the restored channel or allowing sediment to drop out where it is not appropriate. The final design takes into account the length of stream that will be required to maintain the flow force needed to move the sediment when the restored channel is full and begins to spill out onto the restored floodplain.

We understood that we weren't looking at floodplains formed by natural processes. Floodplains we see that are formed by natural processes are much lower. Are these floodplains capable of transporting the bedload that's coming in at this elevation, or do they have to be five feet high to transport the bedload? That's when we started to tie our bankfull discharge into threshold or shear stress analysis to determine at what stress can we move the bedload. If that stress is our maximum and we start spreading it out, we actually provide a lot less stress on the bed and the banks, but we're still capable of transporting the bedload.

– WARD OBERHOLTZER, P.E., CHIEF ENGINEER, LANDSTUDIES, INC.

It's pretty clear at this point that a properly functioning floodplain really is at the fundamental level of what you need to do to restore a stable stream channel.

This holistic approach really makes a lot of sense for us. Why put a riparian buffer on four-foot-high banks when the stream is going to continue to downcut? Access to the floodplain is really key from a stabilization standpoint and diffusion of that energy of the flow. It just totally makes sense and is very logical. Once you understand the impacts that happen in a stream valley and then you look at a stable stream reach somewhere else, you can see how one is stable and functioning and why the other one isn't.

I was always afraid that we were putting a band-aid on some of the areas we were restoring. It wasn't really the holistic approach. Now with the floodplain restoration component in there, I'm pretty well convinced we're not just putting a band-aid on…we're really fully restoring the area to a more stable, functional state.

– CHRISTOPHER KOCHER, PRESIDENT, WILDLANDS CONSERVANCY

BEDFORD SPRINGS RESORT GOLF COURSE
BEDFORD, PA
Floodplain Restoration

Native species were planted in the restoration site and are allowed to grow naturally in areas that are out of play.





This section of Lititz Run near Lititz in Lancaster County, Pa., was channelized and moved to the edge of the stream valley, at the toe of a steep slope. The channel, unstable and eroding, once was used to power a still-standing mill.



The restored channel, narrower and shallower, now meanders through the middle of the stream valley. The floodplain and channel bed were excavated down closer to their historical elevations. Pools in the channel come in contact with groundwater. (The photo on the front cover shows the restoration site from the air.)

BANTA SITE | LITITZ RUN, PA

Flooplain restoration

Riparian wetland (center of photo) interacts with the channel (far left of photo) during high flows. (See page 3 for another view of the channel/ wetlands proximity.)



During the restoration process, tons of legacy sediments are removed from the floodplain area, and when indicated and feasible, all or part of the stream channel within the project site is relocated toward the center of the valley.

Ideally, a full restoration would allow us to remove the legacy sediments from both the channel and the floodplain all the way down to the original cobbles and gravels and would allow the floodplain to occupy most if not all of the valley width. Because of existing constraints, such as buildings, roads, bridges, still-maintained low-head dams, and water and sewer lines, a full restoration is rarely possible, but we are learning how to create a stable system even when we are faced with modern-day constraints. Perhaps the closest to a full restoration, to date, is a project site on Lititz Run, along Route 772 between Lititz and Rothsville in Lancaster County, Pa.

This project, known as the Banta site, lies immediately upstream of an old mill. The pre-restoration channel flowed along the side of the valley, at the toe of a steep hill.

Today, the restored channel — much smaller and shallower — meanders through the middle of the valley. The floodplain rises only a short distance above the surface of the water, and wetlands are frequent along the length of the restored channel. As the restoration makes its own minor adjustments, the interaction between wetland and channel waters is increasing, which is as it should be. Small connecting channels are forming so that the waters intermingle during higher flows.

The restoration site was planted with native grasses, shrubs, and trees, and they are thriving. But something else is happening. Native flowering plants that we did not plant are appearing. This is a phenomenon that happens frequently after a restoration. The original seed bank, which has, for centuries, been covered by legacy sediments, is once again near the surface, and the dormant seeds begin to germinate and grow.

NEW STREET ECOLOGOICAL PARK
SANTO DOMINGO CREEK, PA
Restoration Construction

During the construction phase of a stream and floodplain restoration, there is an unavoidable amount of disturbance, but our construction methods are designed to impart immediate stabilization to the newly restored system, and within a short time the system is much cleaner and more functional than before restoration began.

Some of the numerous benefits of floodplain restoration are apparent soon after the restoration is complete. Others appear over time. And still others may never be visible, but their positive effects nevertheless will be operative.

LEFT TOP: The existing stream was channelized, unstable, and eroding both vertically and horizontally.

LEFT BOTTOM: The locations for segments of the new channel are marked as excavation of the sediment-laden floodplain begins.

CENTER: Aerial view shows the new, meandering channel under construction as water continues to flow through the existing straightened channel.

RIGHT TOP: A closer look at one of the constructed meanders in the new channel.
RIGHT MIDDLE: Sod mats are cut on site and placed along the new, lower stream bank as soon as it is constructed, providing immediate bank stability.

RIGHT BOTTOM: The man is standing on the restored floodplain, now attached to the restored channel. The old floodplain elevation, created by the deposition of legacy sediments, can be seen behind him.















ABOVE:
The meandering path of the restored, shallow channel through the restored floodplain is evident as construction is completed.



ABOVE:
The Santo Domingo Creek restoration site during its first growing season.



RIGHT:
Macroinvertebrate populations quickly rebound and improve in restored stream and floodplain sites.

I imagine there are other exemplar restoration projects, but in Lancaster County, Hammer Creek is the role model. The idea was to change the gradient, improving the riffle/run ratio. The stream channel was moved, new bends and some runs were included in this restoration.

The logical question to ask is 'What happened to the macroinvertebrates?' From an aquatic ecologist's perspective, that's a very important question to ask because, in a stream, the water column is one habitat, the hyporheic zone is another. The hyporheic zone is an often unseen habitat and defined as the region under the stream substrate which includes the water-filled spaces between pebbles, gravel and sand. That hyporheic zone may extend under the stream banks. It is a refugium, and can serve as a nursery, if you will, for small, aquatic invertebrates. Some of them live most of their lives in this hidden dimension of the stream benthos, while some taxa live the early part of their lives there, until they are large enough to improve their survival while living in the water column itself.

When you move a stream channel, what happens to the hyporheic zone? At Hammer Creek, the hyporheic zone was just sand and silt prior to restoration. When LandStudies created a new channel, they created a more diverse habitat – cobbles and pebbles of more sizes and shapes. They provided a suite of substrata or niches and this increase in available benthic microhabitats can only improve macroinvertebrate diversity – if maintained. Thus, within this newly modified channel, the hyporheic zone in the area above the restored area served as new substrata upon which aquatic insects could colonize.

In our study, we evaluated the macroinvertebrate response to restoration by surveying and monitoring two sites within the construction zone and a control site upstream.

Restoration occurred from September to November 2002. While we didn't measure suspended sediment loads or nutrient reduction, we did find that diversity and abundance immediately post-restoration was reduced significantly, probably due to the shock and impact of construction. Within six months, or the following April, we began to observe an increase in macroinvertebrate abundance and diversity. We started to see sensitive taxa that are negatively affected by silt and sediment reappear and continue to thrive in the restored section – something we hadn't observed from our sampling two dates prior to construction.

Another question I had was, once this restoration occurs, what's the downstream impact? So we selected two sites: 100 meters below and a site 2,500 meters below the restored section. Interestingly, over the three years of monitoring these sites, the reaches downstream started to show an increase in diversity as well, so there appeared to be a downstream effect on insect abundance and diversity. Some people may criticize stream and floodplain restoration by saying, 'Well, if you don't do the whole stream what good is it?' I don't know an agency or organization who could undertake the restoration of a whole stream, but if it's done in chunks, you do see a positive effect in aquatic insect diversity and abundance which in turn will influence overall stream functioning as it deals with organic inputs and processing.

While more research is needed to more specifically assess the mechanisms of how stream restoration improves aquatic insect habitat, I think I'm safe to say that our findings suggest that restoration efforts do cause a trauma – both at the site being restored and indirectly to the reaches downstream, thereby impacting the diversity and abundance of aquatic insects initially. However, in my opinion, stream benefits afterward greatly exceed the cost of the initial trauma or not doing anything.

– DR. JOHN WALLACE, PROFESSOR OF BIOLOGY, MILLERSVILLE UNIVERSITY





ABOVE LEFT AND RIGHT:
Stream bank armoring is a common technique used to prevent bank erosion. Unfortunately, it can cause more problems than it solves because the large stones eventually are dislodged from the bank into the channel and contribute to further stream instability.

THE BENEFITS

The benefits of restoring a floodplain are multiple. Here are the ones we know about.

SEDIMENT AND NUTRIENT REDUCTION

Pennsylvania's Nutrient Trading Program provides a market-based approach to facilitate the infusion of funding from municipalities, developers, commercial interests, and others to reduce the amount of sediment and nutrients flowing to the Chesapeake Bay. Floodplain restoration is one of the Best Management Practices (BMPs) included in the program.

There are at least four processes that occur after a restoration that contribute to the removal of sediment and nutrients from the stream flow.

When the floodplain (and often the stream bed) are excavated during a restoration, a substantial source of sediment and nutrients are immediately removed. Removing these materials and stabilizing the new banks can have an immediate and positive effect on water quality.

Because high flows in a restored area now move frequently into the attached floodplain, sediment and nutrients that have washed in from upstream are, to some extent, carried into the floodplain rather than continuing to be carried downstream.

The root systems of native wetland plants in the newly restored floodplain take up much of the nitrogen in the water supply, which keeps it from washing farther downstream or returning to groundwater supplies.

Bacteria that live in anaerobic (oxygen-poor) environments thrive in the saturated soils of a restored floodplain that frequently is inundated not only by rainfall but also by surface water escaping from the stream channel into the floodplain. These bacterial colonies use nitrates instead of oxygen for metabolism, thus eliminating much of the nitrogen from both surface and groundwater.

Twenty years ago we put rock in the channel and that was stream restoration. Then we threw rock in the middle to create fish habitat and maybe some pools. Then we got into the Rosgen approach of natural channel design and the whole definition of stream restoration was changed. Now, hopefully, we're changing the definition to include floodplain management and floodplain restoration. That increases the cost and it increases the benefits, but we need to quantify those benefits. If we can quantify environmental benefits in a broad sense, we'll get more public support for it, and certainly we'd get the regulatory support.

It's to our benefit to look at an ecological approach to stream and watershed restoration with benefits beyond the parameters that we're currently looking at. Those parameters will certainly change as time goes on and we learn more about water quality and processes. By looking at these holistic processes today, we'll be dramatically better off in the future by incorporating floodplain restoration techniques.

– FRED SUFFIAN, NONPOINT SOURCE PROGRAM MANAGER, WATER PROTECTION DIVISION, U.S. ENVIRONMENTAL PROTECTION AGENCY

LandStudies is studying sites throughout Antrim Township in Franklin County, Pa., that can provide maximum benefits through floodplain restoration.



ANTRIM TOWNSHIP PILOT NUTRIENT TRADING PROJECT | FRANKLIN COUNTY, PA

Flooplain restoration for nutrient removal benefits

The biggest concern we hear from municipalities when we discuss alternative methods such as floodplain restoration to reduce nutrients (from sewage plants) is, 'What's our risk?' There are outside economic variables that can play into this, and that becomes risk. For example, relying on a farm for BMPs and then a few years later the farmer either needing to till the land set aside or selling the farm outright to retire. That presents a risk to the municipality.

In DEP's Chesapeake Bay Tributary Strategy, supplemental strategies have been issued for sewage facilities planning. Under Act 537 planning, municipalities can now write their ordinances to say that when a developer walks in the door, he has to bring a certain number of offset credits for every home he's hooking up to the system, or the cash equivalent. It takes the pressure and responsibility off the municipality. That reduces the risk.

We are working with Antrim Township in Franklin County. The Township has elected to examine control of the generation of its own internal nutrient credits and offsets within a planning framework. As a first step, they have incorporated a total municipality-wide assessment of all possible non-point source credits and offsets available. They have begun to categorize, quantify, and identify credit/offset options. The floodplain restoration work is different from farm BMPs because the township can either buy the land or lease it for 100 years, for example, for the restoration. This reduces risk.

With floodplain restoration there's the creation of wetlands, and there's money out there to create wetlands, so that helps offset the cost of this nutrient credit generation. Reducing nutrients and sediment through floodplain restoration on land they control (if purchased or leased) gives them credits which can offset their cap without having to invest as much in treatment plant upgrades, and they may be able to increase the capacity of the plant.

The township can also bank wetlands that have been created through floodplain restoration, then sell wetland acreage to developers who need wetland mitigation for their development. The developer saves lots of time by not having to go through the permitting process for mitigation and the township again recovers part of their cost for restoration.

Risks are an issue but when you begin to minimize your risks, you're putting inherent value into what you're doing. Municipalities need to tie this stuff together. It has to come through the framework of planning, then it has to go into the ordinances. They need to be able to step back and look at the big picture, to see the whole framework they have.

— STEPHEN ZELLER, SENIOR ENVIRONMENTAL CONSULTANT, BRINJAC ENGINEERING





GROUNDWATER RECHARGE AND FILTRATION

A restored stream system allows high flows to move from the channel onto the attached floodplain much more frequently. A portion of that water, along with rain or snow falling onto the floodplain and flowing in the channel itself, will re-enter the groundwater supply. Because the legacy sediments, including impervious clay layers, are removed during restoration, these waters can now more easily infiltrate through the remaining loam and cobble and gravel materials in the floodplain and channel.

Water percolating down through the floodplain will be filtered, or cleansed, because the root systems of the wetland vegetation and the anaerobic bacterial colonies present in the saturated soils will take up some of the nutrients as the surface water works its way back into the groundwater. Additionally, plant root systems in a restored floodplain typically interact frequently with groundwater, which is now near the soil surface. That interaction, too, contributes to the cleansing of groundwater supplies.

In 2005 the Susquehanna River Basin Commission conducted an extensive study in Northern Lancaster County to identify critical aquifer recharge areas (CARAs). Their report of that study[3] includes floodplain restoration as a BMP that can be used to restore CARAs and ensure an adequate and healthy supply of groundwater for public use.

3 Edwards, Robert E., and Pody, Robert D. 2005. Northern Lancaster County Groundwater Study: A Resource Evaluation of the Manheim-Lititz and Ephrata Area Groundwater Basins. Publication No. 235. Susquehanna River Basin Commission.

BUTTERFLY ACRES DRY STREAM VALLEY | LITITZ, PA
CARA Restoration

The Butterfly Acres Trail in Lititz, Lancaster County, Pa., (above left) has been identified as a Critical Aquifer Recharge Area along the length of the drainage swale.

When you're trying to achieve both high density and stormwater management on the same footprint yet protect our waterways, which in many ways have been degraded by sediment deposition, there seems to be a win-win opportunity for achieving highest and best land-use strategies, restoring our waterways, and achieving stormwater management controls and methodology that meet the goals of our state legislators, and that is restoration of our waterways. You're achieving the maximization of the available footprint area on the property by using the floodways for stormwater management through floodplain restoration and taking that five, 10, or even 15 percent in some cases and using it for additional building space.

– MARK HACKENBURG, PRINCIPAL, RGS ASSOCIATES, LAND DEVELOPMENT CONSULTANTS

What's really interesting about what you're doing here in terms of a systems approach, in terms of nutrients and soils and water flow and recharge – all these concepts really do work together truly in the way a watershed should work. We would further argue that many of the BMPs – the big pipe BMPs – different things that just move stormwater from point A to B without taking advantage of natural systems for recharge and infiltration and nutrient removal just contribute to a lot of the water pollution and water quality issues. So part of that system is getting back to native vegetation and ways to improve infiltration.

– NORA GOLDSTEIN, EXECUTIVE EDITOR, BIOCYCLE: ADVANCING COMPOSTING, ORGANICS RECYCLING & RENEWABLE ENERGY

We try to show the state departments with regulatory oversight that one size does not fit all. You have to be able to allow the water to go where it wants to go. Hydrology is not a cookie cutter issue that can be remedied with only one solution.

– JAMES WHEELER, DIRECTOR OF ENVIRONMENTAL AFFAIRS, PENNSYLVANIA STATE ASSOCIATION OF TOWNSHIP SUPERVISORS

STORMWATER MANAGEMENT

Floodplain restoration is now an accepted best management practice in Pennsylvania, as described in the state's Department of Environmental Protection's 2006 publication, Pennsylvania Stormwater Best Management Practices Manual.[4]

As development occurs, increasing amounts of land are converted to houses, stores, parking lots, and other structures that prevent water from soaking into the ground, creating, instead, increasing amounts of stormwater runoff. Traditionally, techniques used to retain or detain stormwater runoff, such as grassy basins and swales, are constructed on site of the developed areas, higher in the watershed than stream valleys. The thought – disputed by some – is that by holding this excess runoff and releasing it slowly, it will do less damage all along the way, from the site down to the bottom of the stream valley. Floodplain restoration, on the other hand, addresses stormwater on a regional or watershed basis, rather than site by site.

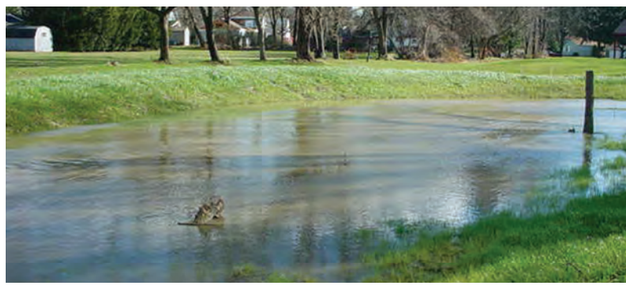
Stormwater management is concerned with both water quality and quantity. We have already discussed how floodplain restoration improves water quality. Let us consider water quantity. When a terrace is excavated so that it can once again act as a functioning floodplain, many cubic yards of legacy sediments are removed. Every unit of largely impervious sediment removed provides an equal amount of space to receive stormwater. And because the restored floodplains are now much more pervious, or porous, much of the runoff that enters the floodplain sinks into the ground rather than moving on downstream.

One of the primary goals of stormwater management is to prevent further damage to our streams by preventing a sudden surge of stormwater from entering the stream system. However, in our unstable stream systems, erosive and depositional damage is occurring with or without the effects of stormwater runoff.

On the other hand, in a stable, restored system, there is little or no legacy sediment to be eroded, and the low banks of the stream channel are well protected from top to bottom by root systems. Thus, the stable, restored system can receive, hold, filter, and move the runoff without being damaged.

4 Pennsylvania Stormwater Best Management Practices Manual. 2006. Document Number 363-0300-002. Pennsylvania Department of Environmental Protection.







LEFT: Detention and retention basins are among conventional stormwater management techniques. RIGHT: Floodplain restoration is a newly recognized, natural, and effective technique for managing stormwater. The restored portion of Santo Domingo Creek (top right) receives flood flows in the now-attached floodplain, where the energy of high flows is dissipated and the flows can be stored, filtered, and infiltrated to groundwater. The erosive energies of high flows in this unrestored section of Santo Domingo Creek (bottom right) are maintained because the flows cannot access the elevated floodplain.



Inadequate openings in this Maryland bridge crossing create debris jams, which, in turn, cause high flows to back up and cause inappropriate flooding.

THE ECONOMICS OF IMPROPER FLOODING

According to the April 2007 issue of the Pennsylvania Township News, published by the Pennsylvania State Association of Township Supervisors, 'Pennsylvania led the nation with an average of $682 million in flood losses each year between 1955 and 1999.'

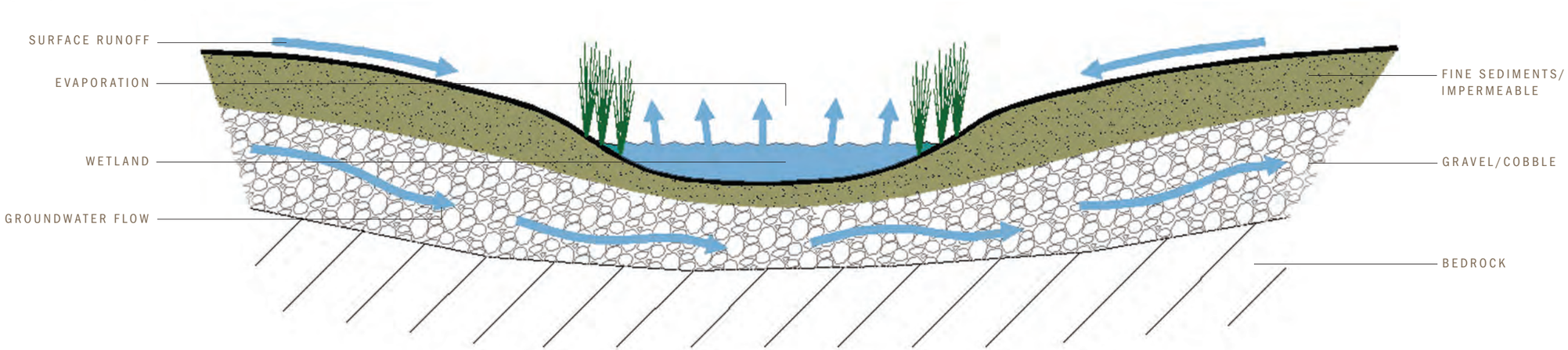
FLOOD CONVEYANCE AND REDUCTION

Flood conveyance and reduction are closely related to stormwater management, and they are of serious economic consequence. Bridges, roads, buildings, and other infrastructure are damaged or destroyed by inappropriate flooding that results from unstable stream systems.

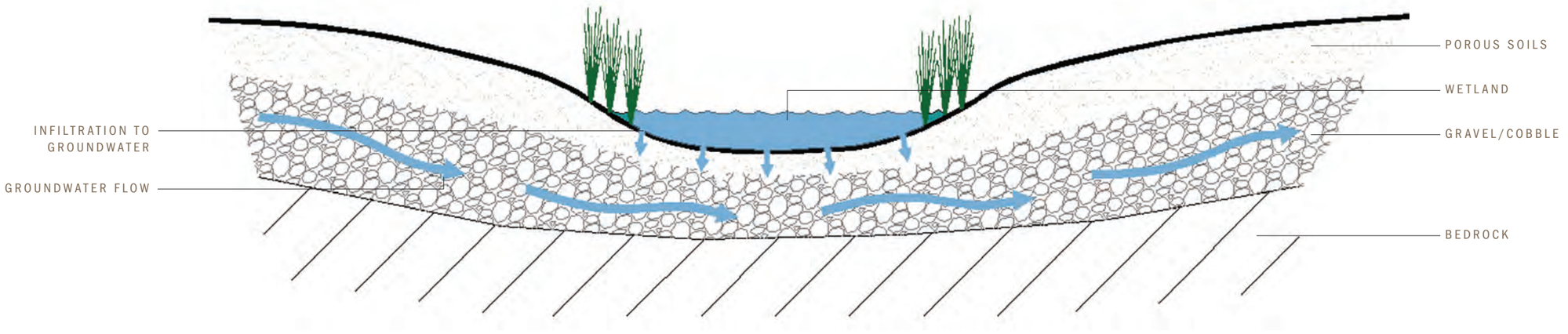
Wetland pockets and functional floodplains help alleviate damaging flooding both in the immediate restoration area and downstream as well. During high flows, water that formerly added to the downstream flow is now dispersed and slowed through restored floodplains, where it filters slowly down through the soil.

An attached floodplain also reduces the erosive forces in the channel and floodplain areas, which helps reduce the number of tree falls in the stream channel, leading to debris jams. Debris jams interfere with the downstream flow, causing water to back up behind them and flood in the wrong areas. In addition, the attached floodplain can trap incoming debris and sediment as water from high flows spills from the channel. This helps reduce the frequency of debris jams at points where downstream flow is constricted, such as bridges, culverts, roads, and railroads.

PERCHED WETLAND



FULLY FUNCTIONING WETLAND



WETLAND CREATION

Many of the wetlands in our landscape are not functioning as fully as they should. That is because they are perched on top of legacy sediments, which, because of their high incidence of clays, are not permeable. These areas are sometimes called “hardpans.” The water collects on top of the legacy sediment and supports wetland vegetation because the water cannot drain through the clays.

Wetlands in a restored stream system are wet in part because they are connected to groundwater, contributing to the interplay between surface flows and groundwater. The result? Improved water quality, flood control, groundwater recharge – all the benefits described above – and improved habitat for both plants and animals.

Floodplain restoration projects improve existing wetlands on the site and typically add additional wetland acreage to the riparian zone.







LEFT : Pickerel Frog
MIDDLE: Great Egret
RIGHT: Redd, or nesting site, for Brown Trout

WILDLIFE HABITAT IMPROVEMENT

A cleaner stream, wetland areas, and a variety of native plants create and improve habitat for both in-stream and terrestrial wildlife, starting with the macroinvertebrate life in the stream and continuing up the food web to fish, reptiles and amphibians, birds, and mammals. The newly restored site will provide food, cover, and nesting sites for a variety of species. The quality of fish habitat improves significantly with the reduction in both sediment erosion and subsequent deposition in the channel farther downstream. Shallow riffles and deeper pools add diverse niches for more species.

If you have a heterogeneous habitat – substrate types that are diverse – pebbles, cobbles, boulders – diversity in depth – you're going to create a habitat that is basically multi-level, which can provide niches for a wide range of fishes and the food they eat. In streams that are extremely burdened with sediment, that's exactly what you see in the stream bottom – a lot of sand and silt. You don't see a lot of substrate diversity. Whatever the pollutant burden – warm water, sediment loadings – the stream will respond ecologically. That burden will decrease diversity at the very base of the wildlife web, and consequently it will reduce the diversity at the top.

– DR. JOHN WALLACE, PROFESSOR OF BIOLOGY, MILLERSVILLE UNIVERSITY

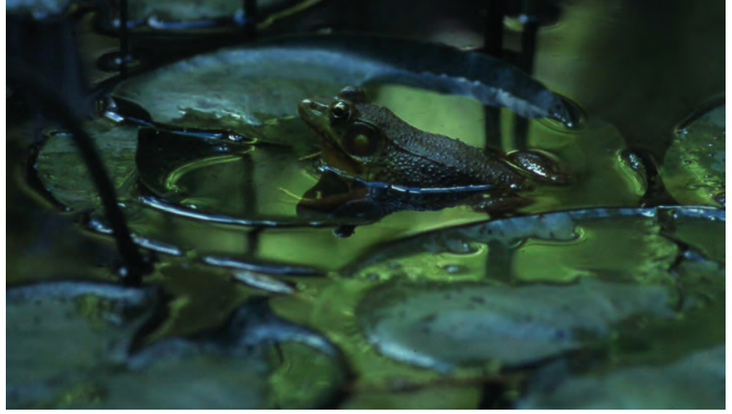
Trout are primarily drift feeders. They feed mostly off things floating in the stream, much like a conveyor belt, some on the surface and some in the water column. They hold in stationary positions where there is protection from the flow of the current. They will hold in that microhabitat, with a very low velocity – approximately two feet per second – with the flow going within inches of their head, so that all they have to do is make a slight movement with their fins and reach out and grab something. They feed primarily on insects, either in nymph stage when they're emerging, or in adult stage when they return to oviposit.

Trout will not hold over sand or silt…they won't be in those feeding positions. They're almost always associated with some sort of stable structure, like boulders, cobble, logs, tree roots, but if the substrate moves, such as silt or sand, the fish won't be there. You can have all kinds of food floating down the stream, but if it has a silty, sandy bottom, the fish will move to find some kind of structure because that's where the food is, and that's where they can get some sort of protection from the force of the current. Those structures provide a differential in the velocity right near the bottom. In my research at Spruce Creek I was able to show that individual fish used the same rock for four successive years with the precision of a quarter of an inch from right to left and less than an inch longitudinally. Now that doesn't mean it's always in just that one spot, but when they move from one feeding station or 'lie' to another, it normally takes only a few seconds to move from one station to another. Clearly these trout are "sit and wait" predators. Brown trout seem to be more specialized in doing this than any of the other trout species. They are experts at not wasting energy.

If all you have is sediment, silt, and sand, don't expect to find many trout. Insects they eat are feeding on algae on rocks, logs, tree roots, and you need a stable surface for the colonization of algae. Insects the trout eat feed on algae or detritus growing on or attached to rocks, logs, and other stable surfaces, or they filter organic material in the stream from stationary positions anchored in or on stable material. Although some of the insects trout feed on burrow in mud and sand, these insects are available to the trout only after they emerge from the sand and silt to metamorphize into adult, ephemeral reproductive forms. As these burrowing insects emerge they get carried along with the current and are captured by the trout waiting for them in their stationary feeding sites.

– ROBERT BACHMAN, RETIRED FISHERIES CONSULTANT, DENVER, PA.













Native vegetation is planted, but often it germinates on its own from uncovered, historical seed banks at floodplain restoration sites. (Photos by Tom Gettings)

Rivers and streams flow through time, and as authors such as Mark Twain, Edgar Lee Masters, and Norman Maclean knew, they tell a story. Often when a floodplain is restored, an untold story reveals itself through the historical plants that spring to life from long-buried seeds that have remained vital after hundreds of years. Their return is a delight to the observer and important to the diversity of life along our waterways.

– JOHN DAWES, ADMINISTRATOR, WESTERN PENNSYLVANIA WATERSHED PROGRAM

INVASIVE SPECIES REMOVAL

The excavation involved with creating a more natural stream channel and floodplain results in the immediate removal of invasive species on the site. The post-construction planting of native vegetation along the stream corridor discourages the re-establishment of invasive, non-native vegetation.

RIPARIAN BUFFER INSTALLATION AND DEVELOPMENT

Appropriate native plants, both herbaceous and woody, provide many benefits to the stream itself and to the water that moves into the floodplain. Trees and shrubs help shade the stream, keeping it cooler and healthier for aquatic wildlife. Leaf litter from these woody plants also provides a source of food for macroinvertebrate life in the stream. And, as discussed earlier, herbaceous plants in the wetland pockets help reduce nutrients through nitrogen and phosphorus uptake.

In many cases, as mentioned earlier, the excavation of legacy sediments in the floodplain uncovers old seed banks of native vegetation that germinate and repopulate the restored floodplain.

TOPSOIL GENERATION

The tons of nutrient-rich topsoil excavated from a stream and floodplain restoration site can be recycled back into farming practices, can be mixed with a wide variety of other materials to create “manufactured” soils for a multitude of uses, or can be used as high-quality topsoil in newly developed or mine reclamation areas. The economic benefits of re-using legacy sediments are just now beginning to be explored.

AESTHETIC ENHANCEMENT

A stable stream meandering through a restored landscape will produce lush green vegetation, bright flowers, and seeds and fruits that will attract a variety of butterflies, birds, and other wildlife species. Restored floodplains can be managed as natural or manicured areas, depending on the site and its intended use.



LEFT: Newly installed riparian buffer along stream in Chester County restored to provide brown trout spawning habitat.

HAMMER CREEK | LANCASTER, PA | Restored floodplain





RIGHT: These two restored sites – one in its natural state (left), the other highly manicured (right) – are along Hammer Creek in Lancaster County, Pa.

The legacy sediment concept is an agricultural issue but it also would be a way for communities to partner. Ag is doing tons of stuff right now and, if we're not careful, the alternative to a farmer not being able to comply with regulations is to sell his farm for development. If we want farmland to remain the backbone of our community, it appears that this stormwater and legacy sediment issue offers communities a way to work together and seek solutions together.

— BILL ACHOR, FORMER ENVIRONMENTAL COORDINATOR, WENGER FEEDS

People have gotten it, all the sudden – that you can't separate what's happening on the ag land over here from what's happening at the wastewater treatment plant and with road runoff. Pointing fingers at the other party has not been constructive.

I think to cobble some of this stuff together right now – floodplain restoration, nutrient trading, stormwater management – is going to take creative people. I think when we look back five years from now, there will be changes we make, but I don't think we're going to say we've gone down the wrong path. I think we'll say we should have done this a little differently, we should have done that a little differently, and then we will.

— MATTHEW EHRHART, PENNSYLVANIA EXECUTIVE DIRECTOR, CHESAPEAKE BAY FOUNDATION

A watershed is everybody's business. That's the sum total of it. It's not just the developer. It's not just the person in agriculture. It's not just the person in business. It's not just recreation. We tend in the Northeast to think of water not as a resource but as a given, as a right. Well, we had a drought a few years ago, and – whoa! – we became aware that water is a resource.

— ROBERT WYBLE, RETIRED ASSISTANT PRINCIPAL, WARWICK HIGH SCHOOL

When you take the example of legacy soils and a municipal yard waste composting operation, if you were just to screen that compost and sell it, you might get $5 a yard, sometimes $10. When you start to bring in a soil and make blends, now you're getting into some high value blends. Whether it's for nurseries or tree farms or where they're taking a lot of soil off and they have to add both soils and nutrients, you can tailor these mixes. The infrastructure's already there. It's a matter of coordinating it.

— NORA GOLDSTEIN, EXECUTIVE EDITOR, BIOCYCLE: ADVANCING COMPOSTING, ORGANICS RECYCLING & RENEWABLE ENERGY

For floodplain restoration to be recognized as a Best Management Practice is one of the first steps that are already being taken in Pennsylvania. Once you have that framework in place, I think it's a matter of educating people that this option is available, along with its multiple benefits. It always takes a long time when somebody brings out a new tool to get other people to use that new tool. It's a matter of putting in place a policy framework that allows all the multiple benefits of floodplain restoration to count, in a restoration sense and a water quality trading sense and a groundwater recharge sense. Once that happens more completely, I think the practice will take off.

— DAVID E. HESS, FORMER SECRETARY, PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

You're either part of the game or you're sitting on the sidelines watching. Me? I'd rather be affecting the outcome. I think that's really powerful. If you want to make a difference, you have to be part of it. The other thing you get out of it is that you already have a heads up. You don't have to react and play catch up. I think it puts us at a business advantage. While everyone is scurrying around to react, we're doing business as usual.

We can incorporate it into our long-term planning. It's part of our natural business operation. We're part of the process. The process is available for everyone. You just have to take that first step to want to get involved. You have to want to make a difference, and there are opportunities there to do that.

It all boils down to the philosophy of wanting to make a difference. It's that simple.

— CHARLIE SOUDERS, MANAGER, ENVIRONMENTAL COMPLIANCE, MCNEIL PPC, INC.



THE FUTURE

The future of stream and floodplain restoration has begun, and where it leads will be limited only by society's imagination and entrepreneurial spirit.

Both Maryland and Pennsylvania, within the Chesapeake Bay watershed, have recognized the environmental and economic value of floodplain restoration and the re-creation of stable stream systems.

Because of the many benefits that result in reconnecting all the components of a stream system – surface water, groundwater, soils, bed material, plants – many sectors of our society stand to gain by contributing to the restoration effort: municipalities, developers, watershed groups, sportsmen, farmers, landowners, businesses, entire communities, and individual citizens.

Entrepreneurs are beginning to see the possibilities associated with Pennsylvania's market-based Nutrient Trading Program and with using legacy sediments to create valuable new soil products.

Research is under way to provide more precise levels of quantification regarding reductions in unwanted sediments and nutrients in our stream systems through floodplain restoration and to understand more fully the numerous processes that feed off each other when stream system components are reconnected to each other.

As we learn more about restoration benefits, and as we come up with new ways to take advantage of those benefits, we also will create new ways to fund and implement this invaluable technique more widely throughout the region.

You are invited to become part of the future of floodplain restoration.

This is the beginning of what is going to be a marvelous journey that has ecological import but also sociological and cultural and historical import.

– KATHLEEN MCGINTY, SECRETARY, PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

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It was the work and understanding of these three persons that helped LandStudies make better sense of all the stream-related problems we were encountering in the field, and which led us to improved techniques for correction and restoration.

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If you want to learn more about stream and floodplain restoration – past, present, and future – here is some additional reading that will provide you with a greater depth of information about the numerous components involved in the amazing natural system of streams and floodplains.

LANDSTUDIES, INC.

http://landstudies.com/

This site contains information about LandStudies' services and projects as well as relevant news articles.

***SUSTAIN MAGAZINE*: A JOURNAL OF ENVIRONMENTAL AND SUSTAINABILITY ISSUES – STREAM RESTORATION ISSUE**

http://louisville.edu/kiesd/sustain-magazine/Sustain24.pdf

This magazine issue, published by the University Of Louisville, Kentucky Institute for the Environment and Sustainable Development, includes numerous articles about stream and floodplain restoration.

"NATURAL STREAMS AND THE LEGACY OF WATER-POWERED MILLING" - *SCIENCE MAGAZINE*

Abstract available at:

http://www.sciencemag.org/content/319/5861/299.short

This article, by Drs. Dorothy Merritts and Robert Walter of Franklin & Marshall College Department of Earth and Environment, describes their research to determine the characteristics of pre-settlement stream systems and the affect of milldams on these systems.

"WATER-POWERED MILLING AND ITS LEGACY AS A SOURCE OF SUSPENDED SEDIMENT TO THE SUSQUEHANNA RIVER AND CHESAPEAKE BAY"

http://www.srbc.net/stateofsusq/documents/LegacySedimentsFeatureArticle.PDF

This article, written by Dorothy Merritts, Robert Walter, and Michael Rahnis, of Franklin & Marshall College, was published in the Susquehanna River Basin Commission Report State of the Susquehanna 2010.



64,000 square-mile Chesapeake Bay Watershed. (USGS photo)

Floodplain Restoration was written and compiled by Shelby Chunko while with LandStudies, who has an extensive background in both communications and the biological sciences. She is particularly interested and talented in effectively communicating complex scientific and technical issues to non-science audiences. Her long-standing interest in environmental issues, her abilities as a writer and editor, and her understanding of LandStudies' approach to floodplain restoration made her uniquely qualified to assume responsibility for the production of this publication.

***The inspiration to create this publication**, "Floodplain Restoration," came from my desire to improve the conditions of our stream systems, both here in Pennsylvania and elsewhere in the region.*

I was blessed to be reared in a family that values the environment. My father was my best friend, who took me camping, fishing, and hunting in Pennsylvania. The rivers and streams of my home state have been my living classroom, and my education in Penn State's School of Forest Resources helped me understand the ecological systems I continue to enjoy.

The waterways and wetlands of Pennsylvania and beyond are true treasures – natural arteries that connect and give life to our diverse regions. From an economic perspective, many of these watery areas have been considered worthless and, in some cases, features to be controlled or eradicated.

For the past 23 years, I have devoted myself to the field of ecological restoration. During that time I have come to appreciate the multitude of variables involved in solving environmental problems: money, government, natural systems, work ethics, and community and personal values are a few that immediately come to mind.

***I believe we are entering a new era of respect for and understanding of our water resources.** I have been amazed at what can happen when a group of dedicated, intelligent, passionate people combine their energies to solve problems, and I am fortunate to be working with many of them. You will read the words of some of them within the pages of this publication.*

You will learn that the subject of this publication – floodplain restoration – addresses a problem that began several hundred years ago. You also will learn that floodplain restoration addresses problems instead of symptoms. I firmly believe that our past tradition of treating symptoms must be replaced with new techniques that respect and restore natural systems if we are ever to see better, longer-lasting results.

Understanding legacy sediments, which are key to many of our problems with water resources, means understanding our own history. We must look back to our past to recognize the opportunities open to us now to improve our environment, our economy, and our communities – not only for all of us today, but for those who will take our place in the future.

***Are we ready to look at new ways of working with the environment?** Are we ready to make the changes that will improve our future? I hope Landstudies' Floodplain Restoration will help you answer those questions for yourself through the first light of understanding.*



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